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LIST OF JOURNALS.

In 1902 Abstracts were made from the following Journals. An asterisk (*) indicates that the Journals so marked were received only occasionally.

Abbreviation.	Full Title.	Price.	Publishers, or Agents.
Acad. Sci. Cracovie, Bull.	Bulletin de l'Académie des Sciences de Cracovie	Single copy, 90 centimes; 8 francs per annum	Librairie de la Société anonyme polonaise, Cracovie
Accad. Lincei, Atti	Atti della R. Accademia dei Lincei, Roma	——	Lungara 10, Roma, Italy
Accad. Sci. Torino, Atti	Atti della R. Accademia delle Scienze di Torino	——	Published by the Academy
Akad. Wiss. Wien, Sitz. Ber.	Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften, Wien	Single copies, 2s. 4d. to 7s. 6d.	Carl Gerold's Sohn, Barbaragasse 2, Vienna
Amer. Acad., Proc.	Proceedings of the American Academy of Arts and Sciences	——	American Academy of Arts and Sciences, 1154, Boynton Street, Back Bay, Boston.
Amer. Electn.	American Electrician	Single copy, 10 cents; $1 per annum	120, Liberty Street, New York
Amer. Inst. Elect. Engin., Trans.	Transactions of the American Institute of Electrical Engineers	Single copy, 50 cents; $5 per annum	Published by the Institute, 95, Liberty Street, New York
Amer. Journ. Sci.	American Journal of Science	$6.40 per ann., post free	Tuttle, Morehouse & Taylor, 125, Temple Street, New Haven, Connecticut, U.S.A.
Amer. Phys. Soc., Bull	Bulletin of the American Physical Society	——	——
Amer. Soc. Mech. Engin., Trans.	Transactions of the American Society of Mechanical Engineers	——	Published by the Society, 12, West Thirty-first Street, New York
Amer. St. Rly. Assoc.	Report of the American Street Railway Association	——	2020 State Street, Chicago
American Telephone Journal	The American Telephone Journal	$1 per annum	116, Nassau Street, New York.
Ann. d. Physik	Annalen der Physik	38 marks per annum	J. A. Barth, Rossplatz 17, Leipzig
Annal. Chim. Phys.	Annales de Chimie et de Physique	36 francs per annum	Gauthier-Villars, Quai des Grands-Augustins 55, Paris
Annal. Scientifiques de l'Univ. de Jassy	Annales Scientifiques de l'Université de Jassy	10 francs per volume	——
Archiv Post Tele.	Archiv für Post und Telegraphie	——	Published by the Reichs-Postamt, Berlin
Archives d'El. Médicale	Archives d'Électricité Médicale	22 francs per annum	O. Doin, Place de l'Odéon 8, Paris

Abbreviation.	Full Title.	Price.	Publishers, or Agents.
Archives Néerlandaises	Archives Néerlandaises des Sciences Exactes et Naturelles	6 fl. per volume	Martinus Nijhoff, La Haye, Holland
Archives des Sciences	Archives des Sciences Physiques et Naturelles, Genève	Single copy, 2.50 francs ; 25 francs per annum	Bureau des Archives, 18 Pélisserie, Geneva
Assoc. Ing. Él. Liège, Bull.	Bulletin de l'Association des Ingénieurs-Electriciens, Liège	20 francs per annum	Rue Sainte-Gilles, 31, Liège, Belgium
Astrophys. Journ.	Astrophysical Journal	Single copy, 50 cents ; 18s. per annum	The University of Chicago Press, Chicago, and W. Wesley & Son, 28, Essex Street, Strand, W.C.
Automobile Club Journ.	Automobile Club Journal	Single copy, 6d.	119, Piccadilly, London, W.
Automobile Rev.	The Automobile Review and Automobile News	Single copy, 10 cents ; $1 per annum	Baltimore Building, 21, Quincy Street, Chicago.
Automotor Journ.	Automotor and Horseless Vehicle Journal	Single copy, 6d. ; 7s. per annum	F. King & Co., Ltd., 44, St. Martin's Lane, London, W.C.
British Optical Journal	The British Optical Journal	Single copy, 6d. ; 5s. per annum	Harp Alley, Farringdon Street, London, E.C.
Bureau des Longitudes, Ann.	Annuaire publié par le Bureau des Longitudes	1 franc 50 centimes	Gauthier-Villars, Quai des Grands Augustins 55, Paris
Cambridge Phil. Soc., Proc.	Proceedings of the Cambridge Philosophical Society	Single copy, 2s. 6d.	C. J. Clay & Sons, Ave Maria Lane, E.C.
Cambridge Phil. Soc., Trans.	Transactions of the Cambridge Philosophical Society	Single copy, 7s. 6d.	C. J. Clay & Sons, Ave Maria Lane, E.C.
Canad. Elect. News	Canadian Electrical News	Single copy, 10 cents ; $1 per annum	C. H. Mortimer Publishing Co., Ltd., Confederation Life Buildings, Toronto, Canada
Cassier	Cassier's Magazine	Single copy, 1s. ; 12s. per annum, post free	33, Bedford Street, Strand, W.C.
Centralblatt Accumulatoren	Centralblatt für Accumulatoren- und Elementenkunde	3 marks 50 pf. per quarter	W. Knapp, Halle a. S., Germany
Chem. News	Chemical News and Journal of Science	Single copy, 4½d. post free	E. J. Davey, 16, Newcastle Street, Farringdon Street, E.C.
Chem. Soc., Journ.	Journal of the Chemical Society	——	Gurney & Jackson, 1, Paternoster Row, E.C.
Chem. Soc., Proc.	Proceedings of the Chemical Society	——	Gurney & Jackson, 1, Paternoster Row, E.C.
Comptes Rendus	Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences	34 francs per annum	Gauthier - Villars, Quai des Grands Augustins 55, Paris

These publications can be obtained from Messrs. Williams and Norgate, 14, Henrietta Street, W.C.

LIST OF JOURNALS—*continued.*

ABBREVIATION.	FULL TITLE.	PRICE.	PUBLISHERS, OR AGENTS.
Deutsch. Phys. Gesell., Verh.	Verhandlungen der Deutschen Physikalischen Gesellschaft	4 marks per annum	—
Dioptric Review	The Dioptric and Ophthalmometric Review	7s. 6d. per annum	17, Shaftesbury Avenue, London, W.
Écl. Électr.	L'Éclairage Électrique	60 fr. per ann., post free	G. Carré & C. Naud, 3, Rue Racine, Paris
Elect. Engin.	Electrical Engineer	Single copy, 3d.; 13s. per annum, post free	139 & 140, Salisbury Court, Fleet Street, E.C.
Elect. Rev.	Electrical Review (London)	Single copy, 4d.; 19s. 6d. per annum, post free	Alabaster, Gatehouse & Co., 4, Ludgate Hill, E.C.
Elect. Rev. N.Y.	Electrical Review (New York)	Single copy, 10 cents; $5 per annum	Times Buildings, 41, Park Row, New York, & H. W. Hall, 42, Old Broad St., London, E.C.
Electrical Times	The Electrical Times and Lightning	Single copy, 2d.; 10s. 6d. per annum	8, Bream's Buildings, Chancery Lane, London, E.C.
Elect. World and Engineer	Electrical World and Engineer	Single copy, 10 cents; $6 per annum	120, Liberty Street, New York, & Hastings House, Norfolk Street, Strand, London
Electrician	The Electrician	Single copy, 6d.; 26s. per annum	Salisbury Court, Fleet Street, E.C.
Électricien	L'Électricien	Single copy, 50 centimes; 25 francs per annum	L. de Soye et Fils, Rue des Fossés-St.-Jacques 18, Paris
Elettricista, Rome	L'Elettricista (Rome)	12s. per annum	Via Cavour 222–226, Rome
Electricity, N.Y.	Electricity (New York)	Single copy, 10 cents; $4.50 per annum	136, Liberty Street, New York
Electro-Chemist	The Electro-Chemist and Metallurgist	Single copy, 6d.; 7s. 6d. per annum, post free	Sherard Cowper-Coles & Co., Ltd., 82, Victoria Street, Westminster
Elekt. Runds.	Elektrotechnische Rundschau	12 marks per annum	10, Kaiserstrasse, Frankfurt a. M., Germany
Elektrochem. Zeitschr.	Elektrochemische Zeitschrift	18 marks 40 pfg. per ann.	M. Krayn, 86, Steglitzerstrasse, Berlin, W.
Elektrotechn. Zeitschr.	Elektrotechnische Zeitschrift	25s. per annum	J. Springer, 24, Monbijouplatz 3, Berlin
Elettricità, Milan	L'Elettricità (Milan)	Single copy, 25 centesimi; 18 lire per annum	5, Via Boccaccio, Milano, Italy
Eng. and Mining Journ.	The Engineering and Mining Journal	$5 per annum	261, Broadway, New York
Engineer	The Engineer (London)	Single copy, 6½d. post free; £1 9s. per ann., post free	33, Norfolk Street, Strand, W.C.
Engineering	Engineering	Single copy, 6½d. post free; £1 9s. 2d. per annum, post free	35 & 36, Bedford Street, Strand, W.C.

These publications can be obtained from Messrs. [illegible]

Abbreviation.	Full Title.	Price.	Publishers, or Agents.
Eng. Club, Phil., Proc.	Proceedings of the Engineers' Club of Philadelphia	$2 per volume	1122, Girard Street, Philadelphia
Eng. Mag.	The Engineering Magazine	Single copy, 1s.; 12s. 6d. per annum, post free	222–225, Strand, London, W.C.
Eng. News	Engineering News	Single copy, 15 cents; $6.31 per annum	220, Broadway, New York, and Effingham House, 1, Arundel Street, Strand, London
Eng. Record	The Engineering Record	Single copy, 12 cents; $6 per annum	100, William Street, New York
Feilden	Feilden's Magazine	Single copy, 1s.; 12s. 6d. per annum, post free	Temple Chambers, Embankment, London, E.C.
France Automobile	La France Automobile	Single copy, 50 cents; 20 francs per annum	68, Avenue de la Grande-Armée, Paris
Frank. Inst., Journ.	Journal of the Franklin Institute	Single copy, 50 cents; $5 per annum	Franklin Institute, Philadelphia
Génie Civil	Génie Civil	Single copy, 1 franc; 45 francs per annum	Rue de la Chaussée d'Antin 6, Paris
Gesell. Wiss. Göttingen, Nachr. Math.-Phys. Klasse	Nachrichten der Gesellschaft der Wissenschaften zu Göttingen, Mathematisch-physikalische Klasse	——	Lüder Horstmann, Göttingen, Germany
Horseless Age	The Horseless Age	Single copy, 10 cents; $4 per annum	E. P. Ingersoll, 150, Nassau St., New York
Ind. Élect.	L'Industrie Électrique	Single copy, 1 franc; 26 francs per annum	A. Lahure, 9, Rue de Fleurus, Paris
Ind. Electrochim.	L'Industrie Électrochimique	Single copy, 60 centimes; 8 francs per annum	H. Becker, 5, Rue Guy-Patin, Paris
Inst. Civ. Engin., Proc.	Proceedings of the Institution of Civil Engineers	——	Published by the Institution, Great George Street, London, S.W.
Inst. Elect. Engin., Journ.	Journal of the Institution of Electrical Engineers	Single copy varies from 1s. 6d. to 7s. 6d.	E. & F. N. Spon, 125, Strand, London, W.C.
Inst. Engin. and Shipbuilders, Trans.	Transactions of the Institution of Engineers and Shipbuilders in Scotland	——	Published by the Institution, 207, Bath Street, Glasgow
Inst. Mech. Engin., Proc.	Proceedings of the Institution of Mechanical Engineers	——	Published by the Institution, Storey's Gate, St. James's Park, London, S.W.
Inst. Naval Architects, Trans.	Transactions of the Institution of Naval Architects	——	H. Sotheran & Co., 140, Strand, London, W.C.

These publications can be obtained from Messrs. Williams and Norgate, 14, Henrietta Street, W.C.

LIST OF JOURNALS—*continued.*

ABBREVIATION.	FULL TITLE.	PRICE.	PUBLISHERS, OR AGENTS.
International Chemical Congress at Paris, Reports	——	——	Gauthier-Villars, Quai des Grands-Augustins 55, Paris
International Electrical Congress at Paris, Reports	Rapports et Procès Verbaux présentés au Congrès International d' Électricité, Paris, 1900	——	Gauthier-Villars, Quai des Grands-Augustins 55, Paris
International Physical Congress at Paris, Reports	Rapports présentés au Congrès International de Physique, Paris, 1900	40 francs	Gauthier-Villars, Quai des Grands-Augustins 55, Paris
Iron and Steel Inst., Journ.	Journal of the Iron and Steel Institute ...	32s. per annum	E. & F. N. Spon, 125, Strand, London.
Journal of Electricity, S. F.	Journal of Electricity, Power, and Gas (San Francisco)	Single copy, 10 cents ...	315, Cherry Street, San Francisco, Cal., U.S.A.
Journ. Phys. Chem.	Journal of Physical Chemistry	$4 per annum	Published at Cornell University, U.S.A.
Journ. de Physique.....	Journal de Physique	15 fr. per ann., post free	11, Rue Rataud, Paris
Journ. Télégraph.	Journal Télégraphique	Single copy, 50 centimes; 5 francs per annum	Bureau International des Administrations Télégraphiques, Berne
Jurn. Russk. Fisik.-Chimičesk. Obščestva	Jurnal Russkago Fisiko-Chimičeskago Obščestva	9 roubles per annum ...	Published by the Russian Physico-Chemical Society, Imperial University, St. Petersburgh
Kongl. Danske Vidensk. Selsk. Kjöbenhavn, Förh.	Öfversigt over Det Kongelige Danske Videnskabernes Selskabs Förhandlinger	5 kr. per annum.....	Andr. F. Höst og Sön, Copenhagen
Konink. Akad. Wetensch. Amsterdam, Versl.	Verslagen van de gewone vergaderingen der wis-en natur-Kundige af deeling der Koninklijke Akademie van Wetenschappen te Amsterdam	——	Published by the Academy
Locomotion Automobile	La Locomotion Automobile	Single copy, 5 centimes; 20 francs per annum	Place de la Madeleine, Rue Chauveau-Lagarde 4, Paris
London County Council, Report	London County Council Report	Single copy, 1s.	P. S. King & Son, 2 & 4, Great Smith Street, Victoria Street, Westminster, S.W.
Manchester Lit. and Phil. Soc., Mem.	Memoirs of the Manchester Literary and Philosophical Society	Single copy, 2s.	36, George Street, Manchester
Mech. Eng.	The Mechanical Engineer	Single copy, 6d.; 20s. per annum, post free	53, New Bailey Street, Manchester
Metallographist	The Metallographist	Single copy, 80 cents; $3 per annum.	Boston Testing Laboratories, 446, Tremont Street, Boston, U.S.A.

Abbreviation.	Full Title.	Price.	Publishers, or Agents.
Monthly Weather Rev.	The Monthly Weather Review	Single copy, 10 cents	Published by the U.S. Weather Bureau, Washington
Motorwagen	Der Motorwagen	16 marks per annum	M. Krayn, 86 Steglitzerstrasse, Berlin, W., 35
N. Cimento	Nuovo Cimento	20 lire per annum	A. Lavacchini, Via Sino Capponi 3, Florence
Nature	Nature	Single copy, 6d.	Macmillan & Co., Ltd., St. Martin's Street, London, W.C.
Nova Scotian Inst., Trans.	Transactions of the Nova Scotian Institute of Science	——	Published by the Institute, Halifax, Nova Scotia
Öfvers. Kongl. Vet. Akad. Stockholm, Förh.	Öfversigt af Kongliga Vetenshaps-Akademiens Förhandlingar, Stockholm	——	Published by the Academy
Page's Mag.	Page's Magazine	12s. per annum	Clun House, Surrey Street, Strand, W.C.
Phil. Mag.	London, Edinburgh, & Dublin Philosophical Magazine	2s. 6d. per month, occasionally 5s.	Taylor & Francis, Red Lion Court, Fleet Street, E.C.
Phys. Rev.	Physical Review	Single copy, 50 cents; $4 per annum	Macmillan & Co., Ltd., London and New York
Phys. Zeitschr.	Physikalische Zeitschrift	5 Mk. per quarter, or 25 Mk. per ann., post free	S. Hirzel, Königstrasse 2, Leipzig
*Popular Science, Monthly	——	——	——
Power, N.Y.	Power (New York)	$2 per annum	Hill Publishing Co., World Building, New York
Preuss. Akad. Wiss. Berlin, Sitzb.	Sitzungsberichte der Preussischen Akademie der Wissenschaften zu Berlin	12 marks per annum	Königliche Akademie der Wissenschaften, Berlin
Railroad Gazette	Railroad Gazette	$6.08 per ann., post free	32, Park Place, New York
Revue de l'El., Berne	Revue de L'Electricité, Berne	8 francs per annum	Place de l'Ours 29, Berne
Revue Int. d'Electrothérapie	Revue Internationale d'Electrothérapie et de Radiothérapie	Single copy, 50 centimes; 6 francs per annum	3, Place du Théâtre Français, Paris
Revue Scientif.	Revue Scientifique	Single copy, 60 centimes; 35 francs per annum	19, Rue des Saints Peres, Paris, and T. F. Unwin, 11, Paternoster Square, E.C.
Rivista Sci.-Industriale	Rivista Scientifico-Industriale	12 lire per annum	2, Lungarno della Zecca, Florence, Italy
Roentgen Ray, Archives	Archives of the Roentgen Ray	Single copy, 2s.	Reman, Ltd., 129, Shaftesbury Avenue, W.C.
*Royal Astron. Society, Monthly Notices	Monthly Notices of the Royal Astronomical Society	10s. per annum	Published by the Society, Burlington House, London, W.
Roy. Dublin Soc., Proc.	Scientific Proceedings of the Royal Dublin Society	Single copy, 6d.	Published by the Society, Leinster House, Dublin

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LIST OF JOURNALS—*continued.*

ABBREVIATION.	FULL TITLE.	PRICE.	PUBLISHERS, OR AGENTS.
Roy. Dublin Soc., Trans.	Transactions of the Royal Dublin Society	——	Published by the Society, Leinster House, Dublin
Roy. Inst., Proc.	Proceedings of the Royal Institution of Great Britain	——	Published by the Institution, 21, Albemarle Street, W.
Roy. Soc., Edinburgh, Proc.	Proceedings of the Royal Society of Edinburgh	Varies for separate papers	Messrs. R. Grant & Son, 107, Princes Street, Edinburgh, and Messrs. Williams & Norgate, 14, Henrietta Street, Covent Garden, London
Roy. Soc. N. S. Wales, Journ. and Proc.	Journal and Proceedings of the Royal Society of New South Wales	——	5, Elizabeth Street, Sydney, New South Wales
Roy. Soc., Phil. Trans.	Philosophical Transactions of the Royal Society of London	Varies for separate papers, from 1s.	Dulau & Co., 37, Soho Square, London, W.
Roy. Soc., Proc.	Proceedings of the Royal Society of London	Varies for separate parts, from 1s. 6d.	Dulau & Co., 37, Soho Square, London, W.
Roy. Soc. Victoria, Proc.	Proceedings of the Royal Society of Victoria	——	Published by the Society, Melbourne. London Agents: Williams & Norgate, 14, Henrietta Street, Covent Garden, W.C.
Schweizerische Blätter für Elektrotechnik	Schweizerische Blätter für Elektrotechnik, Berne	8 francs per annum	Place de l'Ours 29, Berne
Science	Science	Single copy, 15 cents	Macmillan & Co., 66, Fifth Avenue, New York
Scientific American	Scientific American	Single copy, 8 cents; 16s. 5d. per annum, post free	361, Broadway, New York
Scientific Australian	Scientific Australian	2s. 6d. per annum, post free	Turner & Henderson, 16–18, Hunter Street, Adelaide
Soc. Arts, Journ.	Journal of the Society of Arts	Single copy, 6d.	G. Bell & Sons, York Street, Covent Garden, W.C.
Soc. Belge Élect., Bull.	Bulletin de la Société Belge d'Électriciens	Single copy, 2 francs; 20 frs. per ann., post free	54, Rue Froissart, Brussels
Soc. Chem. Ind., Journ.	Journal of the Society of Chemical Industry	30s. per annum	Published by the Society, 9, Bridge Street, Westminster, S.W.
Soc. Franç. Phys., Bull	Bulletin de la Société Française de Physique	——	Published by the Society, 44, Rue de Rennes, Paris

These publications can be obtained from Messrs. WILLIAMS and NORGATE, 14, Henrietta Street, W.C.

Abbreviation.	Full Title.	Price.	Publishers, or Agents.
Soc. Franç. Phys., Séances	Séances de la Société Française de Physique	——	Published by the Society, 44, Rue de Rennes, Paris
Soc. Imp. Nat. Moscou, Bull.	Bulletin de la Société Impériale des Naturalistes de Moscou	——	J. N. Kouchnereff & Co., Pimenowskaia, Moscou
Soc. Int. Élect., Bull.	Bulletin de la Société Internationale des Electriciens	Single copy, 2.50 francs ; 27 francs per annum	Gauthier - Villars, Quai des Grands-Augustins 55, Paris
Street Rly. Journ.	Street Railway Journal	Single copy, 50 cents ; $6 per annum, post free	A. C. Shaw, Hastings House, Norfolk Street, Strand, W.C.
Street Rly. Rev.	Street Railway Review	Single copy, 30 cents ; $4 per annum	Windsor and Kenfield Publishing Co., Monon Building, Chicago
Technology Quarterly	The Technology Quarterly and Proceedings of the Society of Arts (Boston)	$3 per annum.....	Published by the Society of Arts of the Massachusetts Institute of Technology, Boston, Mass.
Terrestrial Magnetism	Terrestrial Magnetism and Atmospheric Electricity	Single copy, 75 cents ; $2.75 per annum	Johns Hopkins Press, Baltimore, U.S.A.
Tram. Rly. World	Tramway and Railway World	Single copy, 1s. post free	Amberley House, Norfolk Street, W.C.
*University Wisconsin, Bull.	——	——	——
U.S. Weather Bureau, Bull.....	Bulletin of the United States Weather Bureau	——	Published by the U.S. Weather Bureau, Washington
*Vid.-Selsk. Forh., Christiania ...	Christiania Videnskabs, Selskabs, Forhandlingar	——	J. Dybwad, Christiania
West. Electn.	Western Electrican (Chicago)	Single copy, 10 cents ; $3 per annum	510, Marquette Buildings, Chicago, and 44, Fleet Street, London, E.C.
Western Soc. Engin., Journ.	Journal of the Western Society of Engineers	$2 per volume of six numbers	Published by the Society, 1734–41, Monadnock Block, Chicago
Zeitschr. Anorg. Chem.	Zeitschrift für Anorganische Chemie	Single copy, 3 marks.....	Leopold Vors, Leipzig
Zeitschr. Elektrochem.	Zeitschrift für Elektrochemie	4 marks per quarter	W. Knapp, Halle a. S., Germany
Zeitschr. Elektrotechn., Wien.....	Zeitschrift für Elektrotechnik (Wien)	30 fr. per ann., post free	Nibelungengasse 7, Vienna
Zeitschr. Instrumentenk.	Zeitschrift für Instrumentenkunde	20 marks per annum.....	J. Springer, 24, Monbijouplatz 3, Berlin
Zeitschr. Instrumentenk., Beib. ...	Beiblatt zur Zeitschrift für Instrumentenkunde		
Zeitschr. Phys. Chem.	Zeitschrift für Physikalische Chemie	Single copy about 4s. 3d.	W. Engelmann, Leipzig
Zeitschr. Vereines Deutsch. Ing.	Zeitschrift des Vereines Deutscher Ingenieure	Single copy, 1 mark 40 pfg. ; 32 marks per annum, post free	J. Springer, Monbijouplatz 3, Berlin

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ERRATA.

Abstract No. 16, line 2 : *for* P. Alfani, *read* G. Alfani.
No. 196, line 1 : *for* H. Luraschi, *read* A. Luraschi.
No. 272, line 4 from end : *for* $u' = W_s$, *read* $u' = U_s$.
No. 272, line 14 from end : *for* $\mu^2 - 2\mu P_s = E$, *read* $\mu^2 - 2\mu = E/P_s$.
No. 272, line 16 from end : *for* $\delta P + \lambda T(T + P - U) = 0$,
read $\delta P + \lambda(T + P - U) = 0$.
No. 304, line 4 from end : *for* $f(t)|F(t) =$, *read* $f'(t)|F(t) =$.
No. 540, last line : *for* + L, *read* /L.
No. 630, line 2 : *for* pp. 164–176, *read* pp. 169–176.
No. 645, line 7 from end : *for* $3 - 7°$, *read* $- 37°$.
No. 897, line 2 : *for* pp. 314–318, *read* pp. 317–318.
No. 999, line 1 : *for* T. R. Coates, *read* F. R. Coates.
No. 1118, line 1 : *for* V. G. Heber, *read* von Georg Heber.
No. 1169, last line : *for* [Abstract No. 353 (1902)], *read* [Abstract No. 533 (1902)]
No. 1186, line 1 : *for* E. Neubery, *read* E. Neuberg.
No. 1240, line 2 : *for* pp. 74–84, *read* pp. 79–84.
No. 1250, line 2 : *for* pp. 159–170, *read* pp. 159–169.
No. 1257, line 2 from end : *for* an increase of energy, *read* a decrease of energy.
No. 1275, line 1 : *for* J. G. Boobnoff, *read* I. G. Boobnoff.
No. 1282, line 3 from bottom : *for* constants, *read* cosines.
No. 1284, line 2 from end : *for* equation *read* equations.
No. 1375, line 2 : *for* W. Gumlich, *read* E. Gumlich.
No. 1377, line 1, etc. : *for* Kirchoff, *read* Kirchhoff.
No. 1383, line 1 : *for* N. Cimento, 3, *read* N. Cimento, 2.
No. 1440, line 2 : *for* pp. 121–130, *read* pp. 128–130.
No. 1500, line 19 from bottom : *for* elequence, *read* elegance.
No. 1516, line 3 : *for* Abstract No. 1536, *read* Abstract No. 1539.
No. 1672, line 2 : *for* pp. 119–136, *read* pp. 119–126.
No. 2101, line 1 : insert Submarine Cables as title.
No. 2340, line 5 from end : *for* street *read* speed.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JANUARY 1902.

GENERAL PHYSICS.

1. *Air-pumps.* **G. W. A. Kahlbaum.** (Ann. d. Physik, 6. 3. pp. 590–602, Nov., 1901.)—This paper contains a useful account of improvements made during the past ten years in the construction of air-pumps of the Sprengel type. Numerous references are given to the author's communications on the subject throughout that time, and also to those of H. Boas, A. Raps, K. Kiss, W. Donle, S. P. Thompson, and others. Of the many kinds of this type now invented the author has examined 150, and has determined their respective merits. The mean performance of the thirty that came first to hand is indicated by the following figures, which show the time occupied in producing a diminution of pressure in a volume of 500 c.c. :—

3 minutes	.....	0·500000 mm. of mercury.	
15 „	.....	0·000165 „	„
30 „	.....	0·000069 „	„

Some interesting figures are given with regard to the maximum degree of vacuum that can be attained. Comparing piston pumps with Sprengel pumps, Neesen with the former in seventeen hours reduced the pressure to 0·000079 mm.; with the latter in five hours he reduced the pressure to 0·000091 mm.; but he does not state the volumes operated upon.

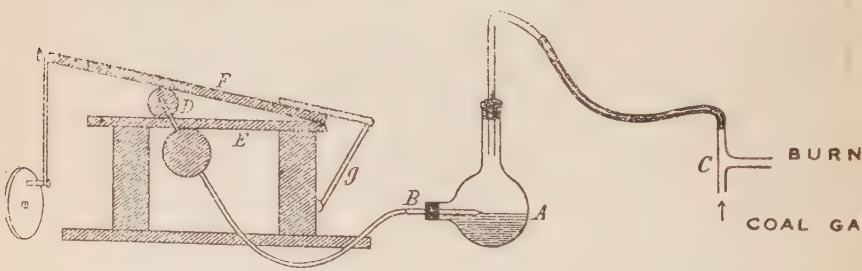
The absence of water vapour is of first importance in attaining these low pressures, and although a drying-tube has the objection of increasing the volume, its advantages outweigh this consideration, at any rate for a well-constructed pump. Speed of operating depends upon the proper adjustment of the proportionality of afflux to the escape of mercury in the tube, and this matter should not be left to the judgment of the glass-blower. When this is attended to, the figure, as above, comes down to the order 0·000002 mm.

In pumps of the Sprengel type the friction of the falling drops of mercury causes electrical discharges to take place in the tube, the effect of which is to erode the glass, and finally to interrupt the working. This question is discussed, and the author shows how it can be obviated by the use of a steel gun-barrel fall-tube. Using all improvements, the author obtained a vacuum of 0·0000018 mm., which is probably the best on record. In order to make glass taps air-tight a substance called *fiomenfett*, prepared by Kress & Co., of Heilbronn, is recommended. R. A.

2. *Glass cocks for Gas Analysis.* **H. Thiele** and **M. Eckardt.** (Ann. d. Physik, 6. 2. pp. 428–431, Oct., 1901.)—Various cocks are described in which special precautions are taken to make them trustworthy for gas analysis work. A perfect arrangement should afford an effective cut-off from external air, and also from any gas that might tend to pass by way of the hole in the conical stopper. As regards ensuring against the admission of external air, this can be done by submerging the cock in mercury; for this purpose it is convenient to hollow out a cork to form a mercury jacket. Oblique boring of the hole in the stopper is of advantage, as it makes more difficult the capillary paths scored around the cone in the process of grinding. Another method of avoiding the effects of these capillary leaks is described by Göckel (Zeitschr. für angew. Chemie, p. 1238, 1900). He uses a hollow cone plug stopper with two or more holes drilled in the same straight line along a side. The plug is always horizontal and is half filled with mercury. The inlet and outlet tubes are parallel to one another, and are both at the top of the horizontal stopper, forming with it a double T-joint when the corresponding holes in the hollow plug are in the "up" position. When these holes are in the "down" position the tubes are cut off from one another, and the holes in the plug are effectively closed by the mercury contained in the plug. This mercury works its way into the capillary scorings, and makes a good cut-off. A drawing is given of an arrangement in which ground surfaces are dispensed with, the gas being shut off by mercury surfaces throughout, in a system of glass tubes, forming an air-trap. R. A.

3. *Cutting Glass.* **G. Roy.** (Journ. de Physique, 10. pp. 614–615, Oct., 1901.)—The author uses a thermocautery for guiding a crack in glass; the glass is touched just beyond the existing end of the crack. Cracks can be turned almost at right angles. A. D.

4. *Apparatus for Producing Coloured Flames.* **Stscheglayew.** (Zeitschr. Phys. Chem. 39. pp. 111–113, Nov. 12, 1901.)—The apparatus figured, for obtaining steady, uniformly coloured flames, is described in the belief that it will materially assist the investigation of such problems as are presented by



the electromotive forces and electric conductivity of flames. A blast of air obtained by compressing the rubber bulb D about 450 times a minute by the aid of a water, or electric, motor, is driven through a narrow tube B into the surface of the solution in A, so that a steady spray passes to the burner. D. H. J.

5. *Optical Measurement of Length Standards.* **A. Pérot** and **C. Fabry.** (Annal. Chim. Phys. 24. pp. 119–139, Sept., 1901.)—The authors give details

of special means which they have devised for applying the interferential method to the determination of the absolute length of standard bars, the system adopted depending on the form of the end of the bar. Many kinds of standard bars are not suitable for the direct application of optical measurements, and in these cases an intermediary mechanical adjustment is fitted to one of the mirrors of the interferometer, the connection of which with the standard bar under examination is regulated by linkwork, so as to be under a known degree of pressure. This pressure is varied, and the resulting deformation plotted, so that, by a slight extrapolation, the length corresponding to zero pressure is obtained, this being presumably equivalent to that which would have been determined if the optical measurement had been direct. Sketches of the modifications utilised for this purpose, and for the maintenance of uniform temperature, are given in the paper. C. P. B.

6. *Distillation of Metals.* **G. W. A. Kahlbaum.** (Phys. Zeitschr. 3. pp. 32–37, Oct. 15, 1901. Paper read before the 73rd Naturforscherversammlung at Hamburg.)—The author has distilled Se, Te, K, Na, Li, As, Sb, Bi, Mg, Ca, Sr, Al, Th, Zn, Cd, Cu, Ag, Au, Ni, Fe, Cr, Zr, Pb, and probably also Sn. Difficulties arising from the want of transparency of porcelain vessels have been overcome by the use of Röntgen rays. The highest temperature which it was safe to use with the apparatus was 1450° (protracted distillation in a vacuum). Under extremely heavy pressures the specific heats of the distilled metals fell very slightly ; the densities first increased, the more so the lighter the deposit had originally been, and then very slightly decreased as the pressure was continued. [See also Abstract No. 1318 (1900).] A. D.

7. *Effect of Drawing on Elasticity of Copper Wire.* **J. R. Benton.** (Phys. Rev. 13. pp. 234–245, Oct., 1901.)—If a copper wire is first annealed by heating electrically to redness, and is then drawn, its modulus of rigidity decreases, and Young's modulus increases. Each successive drawing causes a further diminution of the modulus of rigidity, and a further increase of Young's modulus, the amount of change for each modulus becoming less with each drawing. If the wire is finally annealed, after having been drawn several times, the modulus of rigidity returns to a value considerably greater than its original one, and Young's modulus to one considerably less than its original value. Probably the difference in elastic properties between the wires annealed before drawing and those annealed after drawing is due to the fact that the latter cooled from red heat more rapidly, on account of their smaller diameter, and were therefore more completely annealed. The value of Young's modulus determined by the method of bending proved to be considerably less than that obtained by extension ; but for the annealed wire the values obtained by the two methods very nearly agree. The greater stiffness of drawn wires as compared with annealed wires, which has been often observed, must therefore be due simply to the increase in the *limit* of elasticity. The author gives a full description of his methods, and an analysis of the possible errors, and expresses his results both in tables of numerical values and by plotted curves. W. C. H.

8. *Boyle's Law at very Low Pressures.* **A. Battelli.** (Phys. Zeitschr. 3. pp. 17–21, Oct. 15, 1901.)—The author has repeated and confirmed his former observations [see Abstract No. 1086 (1901)], and has carefully investigated the question as to whether the changes observed were due to absorption by the walls of the containing vessels. He used both glass and iron apparatus.

Carbonic anhydride appears to be more compressed than Boyle's Law would indicate, but this is due, in part at least, to absorption by the walls of the vessel containing the gas. With air, oxygen, and CO_2 there are marked departures from Boyle's law. In the case of hydrogen there is absolutely no absorption, whether glass or iron vessels are used. With air and carbonic anhydride a small absorption is noticed, beginning at a pressure of 1 mm. in glass vessels. The absorption is quite distinct in the case of carbonic anhydride. The following are the principal results of the investigation :—(1) Hydrogen follows Boyle's law from about 1 atmosphere to 0·02 mm. pressure. (2) Air varies from the law between 2 and 5 mm. (3) Oxygen shows a break in the continuity of its behaviour at about 0·7 mm. (4) Carbonic anhydride is more compressed with small pressures than Boyle's law would indicate ; and this phenomenon is probably due to absorption by the walls of the vessel containing the gas.

On the kinetic theory of gases the collisions which take place may give rise to the formation or dissolving of more or less complex molecular groups, and the molecular force of cohesion, on which the formation of these groups depends, may lead to various changes. J. J. S.

9. *Supposed Anomaly of Oxygen at Low Pressures.* **M. Thiesen.** (Ann. d. Physik, 6. 2. pp. 280–301, Oct., 1901.)—Bohr had stated that oxygen deviated strongly from Boyle's law at a pressure of 0·7 mm., and this statement had more or less been confirmed by Battelli, Baly and Ramsay, and others. The author discusses these experiments, especially those of Bohr and of Battelli, and finds that their results do not really agree. Thiesen himself employs the same apparatus in which he studied the behaviour of water vapour. Three balloons, the first two each of 10 litres, the third of 0·8 litre capacity, are connected in series ; the oxygen is generated by heating mercuric oxide. To test the influence of large surfaces, the third balloon was afterwards stuffed with glass wool. Certain peculiarities were noticed in the latter case, but there seems to be no reason for assuming any anomaly at 0·7 mm. pressure. H. B.

10. *Internal Friction of Helium.* **H. Schultze.** (Ann. d. Physik, 6. 2. pp. 302–314, Oct., 1901.)—With helium purer than that used by Rayleigh, but still containing 1·25 per cent. of neon, the author obtains values of η about 10 per cent. above Rayleigh's (1·086 that of air at 15° C., Rayleigh's being 0·96). At temperatures 15°·3, 99°·6, and 184°·6 the values of η are respectively 1969, 2348, and 2699 times 10^{-7} ; whence $\eta_0 = 1891 \times 10^{-7}$, and C = 80·3, while in the formula $\eta_\theta = \eta_0(1 + a\theta)^n$, n has values between 0·6852 to 0·6771, as against Rayleigh's $n = 0{\cdot}681$. In the values of η there were variations of 1 per cent., 1891×10^{-7}, which are at present unaccounted for, but which seem to be related to the time elapsed since previous testings. A. D.

11. *Lines and Planes of Closest Fit.* **K. Pearson.** (Phil. Mag. 2. pp. 559–572, Nov., 1901.)—The author points out that in nearly all the cases dealt with in the text-books on least squares, one of the variables is selected as the independent variable, and the line or plane of closest fit thus obtained depends on the variable selected, and then proceeds to consider the general problem of finding the line or plane which will be the "best fit" to the system of points obtained by plotting the observed variables, all subject to error, in plane, three-dimensioned or higher space, as may be most suitable to the physical, statistical, or biological problem in question. The "best fit"

is taken to be that which makes the sum of the squares of the perpendiculars on the line or plane a minimum. The analogy with the problem of finding moments of inertia then shows that the line or plane required passes through the centroid of the system of points. A complete analytical solution is next given of the problem of finding the "best-fitting" plane, which, when geometrically interpreted, leads to the result that the "best-fitting" plane is perpendicular to the greatest axis of a certain ellipsoid, the ellipsoid of inertia in the analogue, and the minimum mean square residual varies inversely as the length of this axis. The author calls this the *ellipsoid of residuals*, since the inverse square of its radius measures the square of the mean square residual. It is then shown that the line which fits best a system of n points in q-fold space passes through the centroid of the system, and coincides in direction with the least axis of the ellipsoid of residuals. The author then proceeds to express the properties of the best-fitting plane and line in terms of the correlation ellipsoid, but points out that the investigation shows that the q directions of independent variation, and the standard deviations of the independent variables, may be found from the ellipsoid of residuals, which will usually be arithmetically simpler. The paper concludes with some arithmetical examples of applications of the process. G. W. DE T.

12. *Form of Rifle Bullets.* **E. Lampe.** (Deutsch. Phys. Gesell., Verh. 3. 12. pp. 151–162, 1901.)—The surface of the bullet must be a surface of revolution, the axis of which is assumed to coincide with the tangent to the path of the centre of gravity. The resistance of air at constant velocity, perpendicular to a plane, per unit of its surface, is denoted by W_0. If the direction of motion of the bullet be that of negative x, the resistance of that part of the surface of revolution which lies between the ordinates y_1 and y_2 is—

$$W = 2\pi W_0 \int_{y_1}^{y_2} dy\, y \Big/ \left\{1 + \left(\frac{dx}{dy}\right)^2\right\}$$

The integration is effected for surfaces of the second order, especially the hyperboloid of revolution, for which numerical results are calculated. The writer points out an error into which August had fallen, and its correction by Armanini. He also refers to a proof by Kneser that the Newtonian surface of least resistance leads to a minimum resistance in the present problem. The necessary corrections of August's numerical tables are then given. The paper concludes with an example of the mathematical treatment of hyperboloidal functions. [See also Abstract No. 2323 (1901).] S. H. B.

13. *On the Breaking of Waves.* **W. G. Fraser.** (Phil. Mag. 2. pp. 356–361, Oct., 1901.)—According to the ordinary theory of waves in water, applicable in strictness only to small disturbances, a wave reaching an obstacle, such as a wall, is reflected, the two systems of original and reflected waves coexisting. It is found, however, in fact, that large waves instead of being reflected, or wholly reflected, break into spray at the obstacle. And this is the phenomenon which the author seeks to explain.

The explanation given is that the vertical component of velocity is checked by the obstacle, and this tends to produce variation of density, and, if that goes beyond a certain point, breach of continuity. He considers three cases: (1) Waves in deep water with direct incidence; (2) the same for

waves in shallow water ; (3) oblique incidence. If u be the horizontal velocity of an element, v the vertical velocity, so that $u = \frac{d\phi}{dx}$, $v = \frac{d\phi}{dy}$, the author proposes to substitute mv for v, where m is a very little less than unity. That is inconsistent with the equation of continuity unless there be compression. For case (1) of deep waves, it is found that, η being the amplitude and λ the wave-length, the cohesive forces will suffice to prevent rupture of continuity so long as η/λ does not exceed a certain small amount. The result for case (2), that of shallow water, is of the same general character. For case (3), not only the vertical component of velocity, but also the horizontal component parallel to the obstacle is checked, and requires to be affected by a factor n, corresponding to m above. The result is that α being the angle of incidence, the wave will break if $\eta \cos^2 \alpha/\lambda$ exceeds a certain small amount. S. H. B.

14. *Laws of Viscosity.* **L. Natanson.** (Phil. Mag. 2. pp. 342–356, Oct., 1901. Translated from the Akad. Sci. Cracovie, Bull. Feb., 1901.)—The theory of relaxation after strain, originally due to Poisson, has been developed by Stokes and Maxwell. Poisson's ideas, in the view of the present writer, are very important, and lead to a generalised theory of viscosity, of which the accepted theory is a particular case. Natanson starts with the consideration of a perfectly continuous and isotropic fluid, and, employing the usual notation and the classic theory of elasticity, he obtains equations of the types—

$$p^0_{xx} - p_0 = -2n\epsilon^0 - (k - \tfrac{2}{3}n)\Delta^0,$$

and—

$$p^0_{yz} = -nx_0,$$

in which n is the modulus of rigidity, k the modulus of compressibility, and p_{xx}, &c., denote normal pressures, p_{yz}, &c., the corresponding tangential pressures, and p^0_{xx} indicates the value of p_{xx} at an initial instant when $t = 0$. Also Δ is the cubic dilatation, ω its rate of increase per unit of time, and $\epsilon = d\xi/dx$, ξ denoting displacement in the direction x. It is supposed that at a given instant a certain deformation is impressed on the fluid. The system being left to itself, this distortion will gradually disappear by the process of relaxation. A hypothesis is now made that the laws of relaxation may be expressed as follows :—

$$\frac{dp_{xx}}{dt} = -\frac{p_{xx} - p}{T}, \quad \frac{dp_{yz}}{dt} = -\frac{p_{yz}}{T},$$

where T is the "time of relaxation," a constant characteristic of the medium, and p is the normal pressure, uniform in all directions, which would exist in the undistorted medium. The above values for dp_{xx}/dt, &c., lead to equations of the form $dp/dt = -h\omega$ where h is a constant. This is the same result as we should obtain from the hypothesis that the pressure does not vary when $\omega = 0$; and this, as shown, leads to h being equal to k. It appears probable that this relation, $h = k$, holds absolutely, or very approximately, for all fluids in nature, so that $dp/dt = -k\omega$ may be taken as the law of relaxation. It involves the existence of a relation between the pressure p, the density ρ, and the temperature θ of the form $p = p(\rho\theta)$.

A distinction is now drawn between the *true* and the *apparent* deformations of the fluid. The symbols ξ, η, ζ, usually employed to express displacements, relate to those displacements which are evident to our senses, which can in fact be measured. But deformations affecting portions of the fluid too

small for observation may exist, and their physical consequences may be all-important. The hypothesis now made is that Hooke's law extends to fluids, but has to be applied, not to the components of the apparent deformation, but to those of the actual deformation.

Developing the mathematical theory, Natanson introduces two new constants, λ, μ, connected with the constants k and n of the classical theory by the relations—

$$n\mathrm{T} = \mu,$$
$$(k - h - \tfrac{2}{3}n) = \lambda.$$

These are in his theory the two coefficients of viscosity. Stokes, Maxwell, and others have concluded that $\lambda = -2/3 \cdot \mu$. Voigt, on the other hand, calls in question the existence of any relation between the two constants. The writer suggests that some indication of the value of the ratio λ/μ may perhaps be obtained by calculations of the Rayleigh Dissipation function. Natanson says, in conclusion, that the relations $h = k$, and $\lambda = -2/3 \cdot \mu$, though consistent with, are not essential to, his theory of viscosity. S. H. B.

15. *The Mechanism of Radiation.* **J. H. Jeans.** (Phil. Mag. 2. pp. 421–455, Nov., 1901. Paper read before the Physical Society of London, June 14, 1901.)—Jeans considers in this paper certain hypotheses concerning the structure of molecules and atoms by which the phenomena observed in the spectroscope may be explained. The radiation emitted by a gas is supposed to be made up of contributions from a great number of vibrators. It is shown that if each vibrator were capable of rotation about an axis through its centre with an angular velocity p, and if that axis were itself rotating with an angular velocity ω, there would be a spectrum consisting generally of a bright line and a luminous band. If there is to be a line spectrum only, it is found that ω must, on an average, be very small compared with p. From considerations of the law of equal partition of energy [here assumed to be true in fact] Jeans arrives at the conclusion that the atom, and not the molecule, is the vibrator—the exception being the case of monatomic gases, for which, the author says, the law of equal partition fails, and ω is very small. It is inferred that the vibrators, in all gases giving line spectra, are dissociated atoms, and approximately spherical in form—an hypothesis which would explain the fact that pure line spectra are given only by elements. Jeans then considers the structure of an atom as consisting of a great number of point electric charges arranged in spherical shells of alternate signs, the outer shell being always negative. This is assumed to account for the greater importance of negative ions, as shown by Zeeman and others. The mathematical theory of the vibrations of such an ideal atom is worked out *in extenso*, on the assumption of a potential of the form $\rho\rho'\chi_1(r) + \sigma\sigma'\chi_2(r)$ between two charges ρ, ρ', with densities of matter, σ, σ' at distance r, where, as r increases, $\chi_1(r)$ becomes $\frac{1}{r}$, and $\chi_2(r)$ vanishes compared with $\chi_1(r)$. The spectrum of such an ideal atom is discussed. Incidentally the calculations lead to an estimate for the size of an atom ; namely, the radius of an atom of atomic weight n should be, at least as regards order of magnitude, $n^{\frac{1}{3}}10^{-9}$cm. The author then considers how far the spectrum of the real atom may be expected to differ from that of the ideal one.

After some discussion of the Zeeman and Doppler effects, he passes on to consider the structure of the molecule. An atom may consist of $n + s$ positive, and n negative ions, each having a charge e, and s being very small

compared with n, so that at sufficient distances the atom behaves as a point with charge sc. Such atoms may combine to form a molecule, this being defined as a system of ions of which the total charge is zero. From this hypothesis it follows that no free ions can be liberated by chemical change. Also that the force exerted by a molecule at external points falls off very rapidly with the distance. Electrostatically there will be a potential of the form $V = \frac{a_0}{r} + \frac{S_1}{r^2} + \frac{S_2}{r^3} +$ &c., where S_1 S_2 &c., are spherical surface harmonics of orders 1, 2, &c., and a_0 is proportional to the "valency" of the atom. Since by the "integral normal" theorem, $\int 4\pi r^2 \frac{dV}{dr} dS = -4\pi sc$, the result is deduced that a_0/r corresponds to the chemical force between atoms. Between molecules the force will be represented by the subsequent terms in the expression for V. Each molecule will have, generally, a rotational vibration about an axis, which will emit electromagnetic waves. Under certain circumstances this may be converted into continuous rotation, the atom or molecule thus becoming a permanent magnet amenable to Weber's theory. Finally the theory is applied to specific inductive capacity, dielectrics, conductors, and electrolytes. S. H. B.

16. *The Geodynamic Section of the Ximenian Observatory at Florence.* **P. Alfani.** (Rivista Sci.-Industriale, 33. pp. 93–102, 1901.)—The paper, which is a reproduction of one published in the seismological journal of the observatory, describes the microseismographs, seismoscopes, and seismographs collected together in the underground chamber, used in connection with the observatory, for the exact observation and measurement of earth tremors. D. H. J.

17. *Seasonal Variation of Temperature in the British Isles.* **W. N. Shaw** and **R. W. Cohen.** (Roy. Soc., Proc. 69. pp. 61–85, Nov. 8, 1901.)—The harmonic analysis of the curves of mean atmospheric temperature based on the records of the Kew, Aberdeen, Falmouth, and Valencia observatories for the years 1871 to 1895, shows that the primary solar variation is compounded with a secondary half-yearly meteorological variation. This secondary effect, having its maxima in February and August, and its minima in May and November, oscillating in different years over the first ten days of each of these months, moderates and lengthens the winter and intensifies and shortens the summer. The secondary effect is independent of the relative frequencies of cyclonic and anticyclonic weather, but partly due to a periodic variation in the relative frequency of the winds grouped as cold (E., N.E., and N.), moderate (S.E. and N.W.), and warm (W., S.W., and S.) respectively; it differs in magnitude for the several stations, and is not found in the purely Continental stations of Vienna and Agra. A similar effect is observed in the variation in the magnitude of the barometric gradients between London and Aberdeen, and between London and Valencia, and further in the curves of sea-water temperature. The effect of the sea-water can be estimated by the geometrical composition of the harmonic curves, but we have so far very few data. The sea effect would delay all the seasons, and increase the amplitude of the temperature oscillations. As the temperature range of the ocean is small, however, and as its maximum lags considerably behind the planetary effect, these conclusions do not affect the common rule that coast stations enjoy a more equable climate than Continental stations. H. B.

18. *Solar Radiation.* **J. Y. Buchanan.** (Nature, 64. pp. 456–459, Sept. 5, 1901.)—The author gives a general review of the conditions affecting the distribution and retention of the heat received from the sun, with comparative measures at various stations, obtained by different methods. He concludes that the higher values approaching "4" for the "*solar constant*" are much too high, and suggests a value about 1·7–1·8 grm.-calories as representing the best modern determinations. [See also Abstract No. 831 (1901).] C. P. B.

19. *Spectrum of η Argus.* **D. Gill.** (Roy. Soc., Proc. 68. pp. 456–458, Sept. 12, 1901.)—The paper gives a table of the lines measured in the spectrum of η Argus, obtained with the McClean telescope and a slit spectrograph. The spectrum is stated to resemble that of Nova Aurigæ. The photograph used for the reduction was obtained on the nights of April 14, 15, 16, 17, 1899, with a total exposure of 6 h. 10 m. On the same plate a comparison spectrum of the spark of iron was also photographed. The measured wave-lengths of the lines in the spectrum of η Argus are tabulated in conjunction with those observed in the spectrum of Nova Aurigæ. A photograph obtained with an object-glass prism spectrograph is also reproduced, and the derived wave-lengths are given. C. P. B.

REFERENCES.

20. *Spectrum of Nova Persei.* **J. N. Lockyer.** (Roy. Soc., Proc. 69. pp. 133–137, Nov. 19, 1901.)—Details are given in regard to the changes of the spectrum up to September 30, with a discussion of the probable chemical origin of the lines recorded. C. P. B.

21. *Spectrum of Nova Persei.* **W. S. Adams.** (Astrophys. Journ. 14. pp. 158–166, Oct., 1901.)—The paper gives in detail the observed changes in the spectrum of the new star during the earlier part of its appearance. C. P. B.

LIGHT.

22. *Calibration of a Spectrometer Circle.* **V. H. Veley** and **J. J. Manley.** (Ann. d. Physik, 6. 3. pp. 575–579, Nov., 1901.)—The authors describe two simple methods, one of which requires only the aid of two plumb-lines, with the plummets immersed in colza oil to keep them steady. The circle being placed horizontally, the plumb-lines are hung about 5 m. off, so that in ground plan the distance between them subtends an angle of 30° at the centre of the circle. A definite interval of the circle, say that between division 150° and division 180°, is chosen as the standard, the telescope is clamped to the circle, and the distances are adjusted until one plumb-line is seen on the cross-wires when the circle-pointer reads 150°, and the other when the pointer reads 180°. Any other nominal interval of 30° of the circle can then be compared with the standard interval. In the other method the circle telescope does not come into play. A small mirror is fixed on the central table, directly over the axis of rotation. Two small telescopes, A and B, are mounted at distances of about 1·5 m. from the mirror, and from each other, and pointing directly towards the mirror. Their axes produced will thus form an angle of about 60° at the mirror. Telescope A has a fine cross X in front of the object glass. Telescopes and mirror are adjusted so that the reflection of the cross X is on the cross-wires of A when the pointer attached to the central table reads 150°, and on the cross-wires of B when the pointer reads 180°. On clamping the telescopes, and revolving the circle, any interval can be compared with the standard one as before. The author found an average difference of 6″ in an interval of 30°. The errors were sufficient to affect an observation of refractive index to the 5th or 6th decimal place.

A. E.

23. *New Interference Photometer and Pyrometer.* **O. Lummer.** (Deutsch. Phys. Gesell., Verh. 3. 11. pp. 131–147, 1901.)—Herschel's fringes are utilised in this instrument, the essential part of which is a cube formed by placing two right-angled prisms with their hypothenusal bases vertical, and in contact except for a thin layer of air. The observer, looking into one face of the cube with a weak telescope, views the luminous surface under examination directly through the cube, and the comparison surface by reflection at the base of the nearer prism. This comparison surface consists of a translucent disc, placed on one side, with a lamp behind it. The light bands of the transmission fringes coincide with the dark bands of the reflection fringes, and when the two sources are equally bright the fringes vanish. Hence, by the aid of Nicol's prisms, or other contrivances for reducing brightness, the surface under examination may be compared with the standard surface. An advantage of the method is that the fringes in the neighbourhood of total reflection are achromatic, and exceedingly sharp and fine. Several pages are devoted to a discussion of Herschel's fringes, which the author has before shown to be identical with the fringes of a plane plate in parallel light. Formulæ are given for finding the number, position, &c., of the bands. A drawback to all previous photometers is that the comparison object is at a finite distance. Herschel's fringes lie, theoretically speaking, at infinity, yet in actual naked-eye observation they appear on the face of any object viewed

through the cube. When a small telescope is used, the bands and the object viewed will both appear distinct if the latter is at more than 3 m. distance. Thus the instrument can be used for exploring the distribution of brightness in space. In employing the instrument as a pyrometer, recourse must be had to curves showing the connection between temperature and photometric energy. These have been discussed by the author and Pringsheim [see Abstract No. 1290 (1901)], who find that the form of the curve is similar for all opaque bodies. For high temperatures, large errors of observation will make little difference in the result. The author has not yet been able to put his apparatus to a practical test. A. E.

24. *Action of Light on Metallic Surfaces.* **H. Buisson.** (Journ. de Physique, 10. pp. 597–607, Oct., 1901. Ecl. Électr. 29. pp. 7–15, Oct. 5, 1901.)—When a metallic surface is illuminated by sunlight, the rate of loss of negative electric charge steadily falls, until at length the surface becomes in this respect insensitive. Amalgamated zinc can have its surface frequently and uniformly renewed by simply rubbing it with rag or paper. In the dark this change to an insensitive condition does not occur, and the sensitiveness of a fresh surface is even increased, sometimes very considerably, by keeping it for a few hours in darkness. The insensitiveness produced by the light is not permanent, and slowly but completely disappears in darkness. Under the same radiations, a metal becomes more negative by from 0·10 to 0·14 volt, with the exceptions of nickel, which is very slightly affected, and platinum, which is oppositely affected. This modification is not permanent; it disappears gradually and completely in the dark, and under the continued action of light it reaches a limit after a few minutes. The ultra-violet radiations in sunlight play a feeble part in this; those in the arc-light seem to act in a contrary sense to the visible rays, particularly the green and blue, there being a maximum in the violet, beyond which there is inversion in the case of most metals. The variation is independent of the nature of the surrounding gas and of its pressure. Amalgamated zinc, exposed under a photographic negative in sunlight, can afterwards be developed by iodine vapour, Daguerrotype-fashion; the parts protected from the sunlight are the most attacked. The change produced by light is entirely superficial, and does not affect a thick enough layer to enable any effect to be produced upon the state of polarisation of a reflected beam of light. Probably the change of condition is determined by an equilibrium between the surface of the metal and the closely adhering film of gas, probably oxygen, since the metallic surfaces were prepared in air. [See also Abstract No. 1630 (1900).] A. D.

25. *Astigmatic Image of a Horizontal Plane under Water.* **L. Matthiessen.** (Ann. d. Physik, 6. 2. pp. 347–352, Oct., 1901.)—The paper contains a full investigation of the two sets of caustic curves for an eye in a fixed position, and the form of the two resultant images. A. D.

26. *Test Diagram for Stereoscopic Vision.* **C. Pulfrich.** (Zeitschr. Instrumentenk. 21. pp. 249–260, Sept., 1901.)—The diagram, which is meant to be placed in a stereoscope, consists of a pair of circles about 2 inches in diameter, each containing a printed inscription and a series of small geometric designs. It is primarily intended to provide observers using the author's stereoscopic apparatus [see Abstract No. 2094 (1901)] with a means of measuring their capabilities as regards estimation of stereoscopic depth. The

author claims that the diagram may also serve an educational purpose in training children and others to use both eyes alike, and to form correct ideas of space from binocular vision. A. E.

27. *Colour Vision ("Areal Induction").* **G. J. Burch.** (Roy. Soc., Proc. 69. pp. 125–133, Nov. 19, 1901.)—The paper deals chiefly with the explanation of a phenomenon recently described by Bidwell [see Abstract No. 2344 (1901)]. In what is called the "black-spot experiment," a disc of green light is flashed on a screen (or directly on the retina), and followed by a somewhat larger disc of white light with a black spot in the middle. The cycle is completed by an interval of darkness, and then recurs. The impression produced is that of a purple disc with a perfectly black spot in the middle, showing that in the spot area the response to the first (green) stimulus is blocked, or "inhibited," by a second stimulus falling upon a neighbouring part of the retina. The author has introduced an important variation by employing coloured instead of white light for the second stimulus, and thus, in a manner, analysing the process. A full account of the apparatus is given in the paper. It consists of a tube furnished with four lenses, to which is attached a parallel rotating shaft carrying two discs. On placing the eye to the tube a narrow band of colour appears for a moment, followed immediately by a bright patch of monochromatic light filling the rest of the field. A strip of black paper pasted on one of the lenses serves as a background for the narrow band. When the band is a spectrum, and the field red, the appearance of the spectrum is that seen in temporary red blindness. When both stimuli are of the same colour the result has always been the production of a considerable degree of momentary blindness to the second flash, whether the cycle be recurring or not. When the two flashes are of different colours, whatever colour sensations are common to both are blotted out, and the remainder combined, in the resulting sensation. If neither stimulus includes any of the components of the other there is no suppression. Thus purple does not inhibit the response to green. The author says this is difficult to explain on the assumption of an independent white sensation suggested by Bidwell, and he fails to see the necessity for this assumption. If the first stimulus is green, and the second white, then, on Young's hypothesis, the second consists of red, green, and violet. Accordingly the green, which is common to both, vanishes, and the eye perceives that mixture of red, blue, and violet, so familiar in purple pigments. The action called forth seems rather to resemble those reflex ones by which the organs of vision are protected from a sudden light, namely, winking of the eyelids and contraction of the iris. The author concludes his paper by putting forward a definite physiological hypothesis. To quote his own words: "(1) There appears to be strong evidence of the existence in the retina, between the structures in which the visual impulses originate and the beginnings of the optic nerve, of a set of structures by which the intensity of the visual impulses transmitted to the central organ is regulated. (2) These structures are sensitive to light, and when excited, block, wholly or in part, visual impulses coming from the periphery. (3) The structures are cross-connected, so that the excitation of one affects those in its neighbourhood, thus increasing the contrast between a bright object and its surroundings." (He finds no evidence of any such cross-connection between one colour sensation and another.) A. E.

28. *Periodic Changes in Photographic Plates.* **E. Englisch.** (Phys. Zeitschr. 3. pp. 1–5, Oct. 1, 1901.)—Silver bromide gelatine plates (Schleussner

and Herzka) were cut into strips, which were exposed in order to the light from progressively increasing lengths of magnesium wire. On placing the strips side by side after development, alternations of light and darkness on the plate showed that the darkening of the film did not increase steadily with the length of wire burnt, but exhibited a series of well-defined maxima and minima. The contrast between the maxima and minima became more marked when the intensity of the light was increased by placing the plates nearer the burning wire. Experiment showed that the maxima and minima were produced at an early stage of the illumination, and did not alter their position during the later stages. Thus a newly exposed plate is more sensitive than one already solarised. With plates that had first been partly fixed before being developed the maxima and minima were reversed as compared with directly developed plates. The magnesium wire weighed 0·63 grm. per metre, and the lengths burned varied from 2 to 60 cm. The plates were placed at 14 cm. and 20 cm., respectively, from the flame. A. E.

29. *Sensibility of Different Kinds of Undyed Silver Bromide.* **Lüppo-Cramer.** (Phys. Zeitschr. 2. pp. 718–719, Sept. 14, 1901.)—The author states that the sensibility of an undyed emulsion to the less refrangible end of the spectrum is quite independent of its sensibility to the blue. He exposed for the same time to red and yellow light an instantaneous plate and one coated with pure silver bromide, and found, on development, that the latter was strongly blackened, while the former showed hardly any reduction.

E. C. C. B.

30. *Optical Rotation of Cane-Sugar in Pyridine Solutions.* **G. M. Wilcox.** (Journ. Phys. Chem. 5. pp. 587–599, Nov., 1901.)—On studying the optical rotation of cane-sugar dissolved in pyridine, the author obtains the following results, the numbers given referring in all cases to the D line of the spectrum: The specific rotation at 25° varies from 86·7 for a 1 per cent. solution to 83·6 for a 6·25 per cent. solution of the sugar, the change being much greater than for aqueous solutions of the same range of concentration, and in the opposite direction. The influence of alteration of temperature is also very great, the specific rotation of a 6·25 per cent. solution varying from 88·7° at —10° to 77·0° at 105°. The effect of adding increasing quantities of a 6·25 per cent. aqueous solution of cane-sugar to a solution of similar strength in pyridine, is at first a rapid diminution of the specific rotation; the values at 25° for mixtures containing 100, 90, 80, 60, 40, 20, and 0 per cent. of the pyridine solution are 83·8°, 77·9°, 73·2°, 69·4°, 67·2°, 66·0°, and 66·6° respectively. Measurements of the change of boiling-point of pyridine when cane-sugar is dissolved in it give, for the sugar, molecular weights which increase considerably with the proportion of sugar present. T. H. P.

31. *On Rotatory Polarisation in Biaxial Crystals.* **H. C. Pocklington.** (Phil. Mag. 2. pp. 361–370, Oct., 1901.)—The rotation of the plane of polarisation of transmitted light has been observed in uniaxial crystals, *e.g.*, quartz. In the present paper theoretical reasons are given for its occurrence in biaxial crystals, and the general mathematical treatment of the subject for this purpose is given. The special case of the form of the wave surface near an axis are next discussed. It is then proved that the two waves propagated in any direction are elliptically polarised, and that the ellipses are similar, but with corresponding axes perpendicular. The author then discusses the case of a plate in convergent polarised light, and that of a pair of such plates of

opposite rotatory power (Airy's spirals). The formulæ are then extended to crystals, in which the rotation is due to the arrangement of the molecules. In these cases, the forces causing the rotation are assumed to be the same for all directions of propagation of the wave, but they produce, generally, a visible effect only when the direction of propagation nearly coincides with an axis. Certain experiments are described which were made by the author with plates of cane-sugar cut perpendicular to an axis, and 0·4 to 0·8 centimetres thick. These experiments confirm the mathematical results. S. H. B.

32. *Magnetic Rotation of Light and Thermo-dynamics.* **Rayleigh.** (Nature, 64. pp. 577–578, Oct. 10, 1901.)—In a former paper the author drew attention to a peculiarity of the magnetic rotation of the plane of polarisation arising from the circumstance that the rotation is in the same absolute direction whichever way the light may be travelling. A consequence is the possibility of an arrangement by which the usual optical law of reciprocity is violated. "A point source A would thus be visible at a point B, when a source at B is invisible at A, a state of things *at first sight* inconsistent with the second law of thermo-dynamics." Wien, in a recent report [see Abstract No. 1083 (1901)] considering the same combination of Nicols and magnetised dielectric, arrives at the conclusion that the inconsistency actually exists. Rayleigh points out that this conclusion is due to an oversight in the reasoning. A. E.

33. *The Spectra of Hydrogen and some of its Compounds.* **J. Trowbridge.** (Phil. Mag. 2. pp. 370–379, Oct., 1901.)—The author has concluded [see Abstract No. 59 (1901)] that the so-called line-spectrum of H is due to water vapour, and that a certain amount of the latter is essential in all electrical discharges through gases. He considers that "pure H is a perfect insulator, and that the passage of electricity depends on the dissociation of H and O, by means of which change in the distribution of energy the gases are made luminous." V. Schumann [see Abstract No. 1483 (1901)] showed that pure H at atmospheric pressure transmits ultra-violet rays as well as the most perfect vacuum attainable. Maxwell's electromagnetic theory of light demands that the space between us and the sun should be a perfect insulator, otherwise the electromagnetic waves would be completely absorbed, and the earth would remain in darkness. Dewar has proved that liquid H is an insulator. The author attributes the reduction of the luminosity of a wire when an atmosphere of CO_2 is suddenly replaced by H, not to the better heat-conductivity of the latter, but to the increased resistance owing to the occlusion of H. Palladium often increases 50 per cent. in this way. "The increased length of the spark in H is not due to increased conductibility, but to dissociation of water vapour." A number of new experiments are described, supporting the author's thesis that the vapours of water and hydrocarbons are invariably present in luminous hydrogen tubes, one of the most striking being that the copper thrown off from the positive terminal was converted into "an olive-green oxide," while that from the negative was metallic. "A steady current passes through a gas at comparatively low pressure, much in the same manner as it does through an electrolyte." A number of different gases were tried with carbon electrodes, and the phenomena were very similar. With powerful condenser-discharges, oxygen is set free from commercial aluminium and magnesium. "The brilliancy of the light of tubes filled with hydrogen diminishes as the process of dissociation of water vapour goes on, and the resistance of the tube increases. It is possible to raise such a tube to the X-ray stage from a pressure of 1–2 mm., merely by the application of

strong, steady current, the X-rays then being due to the radiations set up by the dissociation of highly rarified water vapour." Measurements and photographs of the lines are given. The research was carried out at Harvard University. S. R.

34. *The Absorption Spectrum of Chlorine.* **E. R. Laird.** (Astrophys. Journ. 14. pp. 85–115, Sept., and pp. 215–216, Oct., 1901.)—The author has photographed the absorption spectrum of chlorine with a 15-ft. Rowland grating, using a column of the gas 1·37 metres long. The spectrum consists of the broad absorption band in the violet already investigated by Liveing and Dewar (Chem. News, 47–121, 1883) and a line spectrum, which, at atmospheric pressure, extends from $\lambda 4799 - \lambda 5350$, and bears no apparent relation to the emission spectrum of this gas. The effect of varying the pressure of the gas was studied, and, as regards the wave-lengths of the line spectrum, no appreciable result was observed, while the large absorption band is considerably altered in breadth, but is not resolvable into lines at any pressure. For this reason the author considers the two spectra to be quite distinct and very possibly arising from different molecular complexes. In general, as the atomic weight increases, the lines in the absorption spectra of the halogens tend to shift towards the red, and to increase in number and sharpness. E. C. C. B.

35. *The Electric Spark and its Spectrum.* **C. C. Schenck.** (Astrophys. Journ. 14. pp. 116–135, Sept., 1901.)—By a study of the changes produced in the spark spectrum of cadmium by variations in the period of the condenser, due to self-induction, the author divides the lines into three groups: group A, containing the so-called arc lines; group B, containing most of the spark lines; and group C, consisting of lines which extend only a short distance from the poles, and which disappear when self-induction is introduced. The mechanism of the spark was investigated by means of a revolving mirror. Photographs of the curved streamers were obtained, which show that the latter originate at the kathode. The lines of group B are the result of these oscillations only, while those of group A are due partly to them and partly to a luminosity which commences in the centre of the spark-gap a trifle later than the first discharge, and persists some time after the oscillations cease. Under the influence of a magnetic field, also, the lines of groups A and B show quite different behaviour. E. C. C. B.

36. *Magnetic Rotatory Dispersion of Sodium Vapour in the Interior of an Absorption-Line.* **O. M. Corbino.** (Accad. Lincei, Atti, 10. pp. 137–138, Sept. 15, 1901.)—Experiments are described to demonstrate this effect by the inflection of horizontal fringes in the same direction on each side of a Fraunhofer line; but within the line they are on the whole not much displaced; the rotation cannot be more than 18°, which is at variance with theory, according to which it should not be less than 200°. A. D.

37. *Structure of Spectra on the Electron Theory.* **W. Sutherland.** (Phil. Mag. 2. pp. 245–274, Sept., 1901.)—The paper introduces various suggestions, with confirmatory reasoning, in the endeavour to trace the structure of spectra to two facts—(*a*) that the atoms vibrate as deformable, but practically incompressible, bodies of finite calculable rigidity, so that their surfaces have stationary waves corresponding to the fundamental mode of vibrations and its harmonics; (*b*) that electrons, in describing nearly circular orbits round

an atom, out of an infinity of such orbits possible, have orbits of certain frequencies made predominant by resonance. The orbits for a positive electron will be different from those of a negative one, and thus a relative motion between the two will be set up. Regarding these motions as taking place at different angular velocities in a circular path, formulæ are derived which explain Balmer's and Rydberg's formulæ, and further, Rydberg's laws lead to the conclusion that the fundamental angular velocity of all electrons associated with atoms is a constant representing a frequency of 33×10^{14} per second. The mechanical periods of vibration of the atoms are calculated from the rigidities of the metals at absolute zero, and are proved to exhibit simple harmonic relations. The spectra of different elements thus appear to be caused by practically one and the same form of electrical appliance, a pair of electrons, which is supplied with energy by the atom at various internodes. One spectrum would thus be only a slight kinematical variation of another. C. P. B.

38. *Complete Emission Function.* **P. G. Nutting.** (Phil. Mag. 2. pp. 379–386, Oct., 1901.)—The author developes the Wien formula expressing the relation between emission, temperature, and wave-length of the radiation from a perfect radiator, by first considering separate functions for temperature and wave-period, and then combining them, with the necessary limitations suggested by experiment. The resulting functions are then extended to apply to the emission from partial radiators. [See also Abstract No. 502 (1901).] C. P. B.

39. *Emission Function of Body Emitting a Line-Spectrum.* **A. W. Porter.** (Phil. Mag. 2. pp. 573–574, Nov., 1901.)—The author gives a single term formula to represent the radiation of hydrogen, in place of the series formula suggested by Nutting (see preceding Abstract), and, by means of the Wien radiation function, gives an expression capable of representing the whole series of spectra of an element. C. P. B.

40. *Röntgenised Air.* **E. Villari.** (N. Cimento, 2. pp. 131–144, Aug., 1901. Rend. della R. Accad. Sci. di Bologna.)—The author employed a similar apparatus to that used in his previous experiments [see Abstract No. 1643 (1901)]. The Crookes tube was enclosed in a lead case with an aluminium window; this and the coil were enclosed in an earthed zinc case. Opposite the aluminium window was placed the aluminium window of a second lead case provided with inlet and outlet tubes, through which air was driven, and Röntgenised in its passage. The following is a summary of the experimental results:—When Röntgenised air was passed through an insulated zinc tube, and one pole of a dry pile was held near the wall of the tube at its outer end (but out of the current of air), the tube became strongly charged with electricity of the same sign as that of the pole. There was no charge unless the air were Röntgenised. As the distance between the pole and the end of the tube increased the charge diminished, and practically no charge was perceptible when the distance was 30 cm. If the tube be earthed and the air allowed to impinge on a metal ball, this becomes charged in the same way.

A screen placed between the tube outlet and the pole of the dry pile prevents the tube or ball becoming charged. This tends to show that the air reaches the pole by diffusion, and communicates its charge to the tube, but this view is contradicted by the following facts:—The air in issuing from the

tube was found to draw air with it from the pole. If the tube be surrounded by a second metallic tube, concentric with and insulated from it, and the pole of the dry pile be placed near the outer tube, the inner tube becomes charged as before, while the outer takes the opposite induced charge. The same result is obtained if the inner tube be of glass. G. H. B.

41. *Magnetic Analysis of Radium Rays.* **H. Becquerel.** (Comptes Rendus, 132. pp. 1286–1289, 1901.)—An improvement is described on an earlier arrangement of apparatus [see Abstract No. 1077 (1901)], and by means of screens, apertures, and sensitive plates, a homogeneous radiation can be produced and recognised. It is found that the undeviated rays, and those least deviated by a magnetic field, traverse a thin aluminium plate without absorption, and produce little or no secondary radiation. The rays deviated, and partially absorbed, pass through the aluminium without change of path, and excite intense secondary rays on each side of the aluminium. Secondary rays are shown to have a constituent which suffers deviation, and the mean curvature of secondary rays emitted by lead is in the same sense, and appears to be of the same magnitude as that of the exciting rays. G. E. A.

42. *Radio-activity induced by Kathode Rays.* **J. C. McLennan.** (Phys. Zeitschr. 2. pp. 704–706, Sept. 7, 1901.)—The only case of radio-activity induced by kathode rays in a neutral substance has been that of bismuth, discovered by Villari. The author finds that a very large number of salts are brought to a condition in which warming them makes them radio-active for a short time, the supply of negatively charged particles discharged from the surface then coming to an end. A. D.

43. *Influence of Becquerel Rays on Bacteria.* **E. Aschkinass** and **W. Caspari.** (Ann. d. Physik, 6. 3. pp. 570–574, Nov., 1901.)—An account of some experiments which show that Becquerel rays, like ultra-violet light, exercise a harmful influence on the development of some kinds of bacteria. R. S. W.

44. *Physiological Action of Radium Rays.* **H. Becquerel** and **P. Curie.** (Comptes Rendus, 132. pp. 1289–1291, 1901.)—Curie has repeated Giesel's two hours' experiment, exposing the arm to the action of radium for 10 hours, the active barium chloride used being relatively feeble (5,000 times that of uranium). After the action the skin was red, having the appearance of a burn, but with little or no pain. After some days the redness was intensified, but did not spread. After 20 days a crust formed, then a sore, which was dressed; after 42 days the skin began to form round the edges, but a sore 1 sq. cm. in area still remained at the end of 52 days. Becquerel carried in a waistcoat pocket a small sealed glass tube containing several decigrams of very active radiferous barium chloride (800,000 times that of uranium). The tube, wrapped in paper, was carried in a small cardboard box on two successive days, the total exposure being 6 hours. After 10 days a long oval spot appeared on the skin. This became redder, and after 20 days the skin began to peel, and the part most attacked to suppurate. The sore was dressed, and it healed in 49 days after the application of the rays, leaving a cicatrice. These and other experiments show that the time required for the effect of the rays to develope varies with their intensity, and with the time of exposure. The handling of tubes and capsules containing active products caused an action on the hands and nails, resulting in pain and peeling of the skin. G. E. A.

HEAT.

45. *Thermometry.* **L. Holborn.** (Ann. d. Physik, 6. 2. pp. 242–258, Oct., 1901. Communicated by the Phys. Tech. Reichsanstalt.)—The first part of this paper describes the method of comparison of certain platinum thermometers with a hydrogen standard, using liquid air for the lower temperatures, the lowest temperature attained being —182°·7. For platinum the mean resistance value for three thermometers is—

$$R = R_0 (1 + 0{\cdot}003934t - 0{\cdot}000000988t^2).$$

In the second part a similar comparison is made for nitrogen, using the same platinum thermometers and reducing the results to the hydrogen scale. At a temperature of —190°·0 on the hydrogen scale the nitrogen thermometer reads about —190°·5, in each of seven recorded observations. In comparing platinum thermometers with nitrogen thermometers at high temperatures the temperature bath used was potassic nitrate heated electrically, as described by L. Holborn and A. Day [see Abstract No. 2003 (1900)]. The results obtained are compared with those of Chappuis and Harker, and also with those of Callendar, Dickson, and Dewar. As a check upon the validity of the equation for the platinum thermometer at low temperatures, the boiling-point of liquid oxygen was observed, and was found to be —182°·7 C.

Various substances were examined with a view to finding one suitable for liquid expansion thermometers for temperatures as low as the boiling-point of liquid air. Petroleum ether was finally adopted, but as it can scarcely be regarded as a definite substance, the authors do not consider it to be altogether satisfactory. For their purpose they selected a commercial sample boiling at 33° C., and distilled from it at 25°–30° the liquid for their experiments. [The dephlegmator appears to have been of rather a primitive form, so that the resulting substance is perhaps less definite than it need have been.] In conclusion, the petroleum thermometers are compared with platinum thermometers, the deviations at different temperatures on different days are tabulated, and some notes are given as to the difficulties of construction of petroleum thermometers. R. A.

46. *Isothermals of Mixtures of Hydrochloric Acid Gas and Ethane.* **N. Q. Gzn.** (Zeitschr. Phys. Chem. 39. pp. 14–26, Nov. 12, 1901.)—Extensive observations were made on the behaviour of various mixtures of HCl and C_2H_6. The corresponding values of the volume and pressure at different temperatures are given in a set of tables and are shown by curves. The main points of the theory of the behaviour of mixtures of two substances as given by van der Waals and others are confirmed by the experiments. J. J. S.

47. *Law of Equal Partition of Energy and van der Waals' Theorem.* **S. H. Burbury.** (Phil. Mag. 2. pp. 403–417, Oct., 1901.)—The law asserts that for a system of molecules in stationary motion within a space bounded by elastic walls impermeable to heat, the chance of the coordinates lying between x_1 and $x_1 + dx_1$, . . . &c., is proportional to $\epsilon^{-2h\chi} d\sigma$, where h is 4/3 of the mean kinetic energy of each molecule, a constant ; $d\sigma$ the continued product of the differentials $dx_1 dy_1 \ldots dz_n$, and χ is the potential of all the forces acting on

the molecules in that configuration. Boltzmann's proof (Vorlesungen über Gas Theorie, part i. p. 134) assumes that the molecular velocities are independent, which leads to the expression $A\varepsilon^{-h\Omega}d\sigma d\psi$ for the chance of the molecules having their coordinates between the foregoing limits, and their velocities within the limits u_1 and $u_1 + du_1 \ldots w_n$ and $w_n + dw_n$; where $d\psi$ is the continued product of the velocity differentials, and $\Omega = \Sigma m(u^2+v^2+w^2)$, a function of the masses and velocities only, while A is, omitting numerical factors, a function of the coordinates only. It then easily follows that $A = \varepsilon^{-2h\chi}$, which the author prefers to modify into $A = \varepsilon^{-2h\Sigma\chi}$, where χ is now for any molecule the potential of all the forces acting on it, including intermolecular forces. The author then shows that wherever this law is applicable there must be inequalities of density. These will not be measurable, as the mean density will be constant for the smallest measurable volumes, the number of molecules in each being practically infinite. Non-linear functions of the densities, however, such as the potential, and the virial of the intermolecular forces, cannot have in the irregular system the same mean value as if the density were uniform.

The author then discards Boltzmann's fundamental assumption, and taking for Ω the more general form—

$$\Omega = \Sigma m(u^2 + v^2 + w^2) + \Sigma\Sigma b_{ik}(u_i u_k + v_i v_k + w_i w_k),$$

where b_{ik} is a function of the distance r_{ik} between the two molecules to which i and k relate, he obtains a modified form of Boltzmann's law expressed by $A = \varepsilon^{-h\Sigma\mu\chi}$, where μ is a function of the masses and of b_{ik}, being a constant when all the molecules are similar, and, in the limiting case of an infinitely rare medium, unity. The physical results are of the same general character as those of Boltzmann's.

The author then propounds the question, "Is not the law, whether in Boltzmann's, or in the modified form, the characteristic of gas, as distinguished from other states of matter?" This leads to the consideration of van der Waals' theory, according to which the gaseous and liquid states are continuous, and the author's conclusion is that though both Boltzmann's law and the theory of van der Waals are doubtless true, they cannot both hold good for the same substance in the same state. For a gas contained in a cylinder with an air-tight piston and slowly compressed so as to maintain the motion in the stationary condition, Clausius' equation gives $\frac{3}{2}p\omega = T + U$, where p is the pressure on the piston, ω the volume of the gas, T its kinetic energy, and U the virial of the intermolecular forces, supposed wholly attractive, so that U is negative. The density is then, in van der Waals' theory, assumed constant, and therefore proportional to $1/\omega$; also that the resultant of the intermolecular forces vanishes except close to the boundary. U there varies as $1/\omega^2$, giving the factor $p + a/\omega^2$ in van der Waals' equation

$$\left(p + \frac{a}{\omega^2}\right)\left(\omega - b\right) = rT.$$

Now if the law $\varepsilon^{-2h\chi}$ prevail, this uniform distribution is impossible, except perhaps in the limiting case where the density is so great that any deviation from uniformity would make χ infinite. Therefore the two laws cannot coexist. The assumption of van der Waals that the finite intermolecular forces are wholly attractive would tend to increase the want of uniformity—in fact, if Boltzmann's law applied, the perfectly uniform distribution assumed

by van der Waals would then be the most improbable of all possible ones. The former law is true for gases: if the latter is also true for gases there must be a sharp dividing line on one side of which Boltzmann's law holds and on the other that of van der Waals. Boltzmann's analysis does not admit of any such abrupt change, which, however, would occur, with certain volume and temperature conditions, under the author's modified form of the law, through the changing of sign of Q. This cannot, however, be considered as removing the difficulty inherent both in Boltzmann's law and its modification by the author. The modification merely suggests possible means of escape. The author points out that molecular streams must necessarily result from the variations in density, and therefore molecules of unequal masses cannot have equal mean energies of translation. His former conclusion [see Abstract No. 506 (1901)], that the energy which is equally partitioned is not the whole energy of translation, but only a certain definite portion of it, is therefore confirmed.

Against Boltzmann's proof of the law of equal partition (Vorlesungen, part ii.), which agrees in substance with those of Maxwell and Rayleigh, he makes the following objection. Expressing the kinetic energy of a system in the form

$$E = a_1 r_1^2 + a_2 r_2^2 \ldots + a_n r_n^2,$$

where r_1, r_2, &c. are Boltzmann's "*momentoids*," the latter's proof implicitly assumes that all combinations of the r's which satisfy this are equally probable, which is no more self-evident than the proposition which it is employed to prove. What is really proved is, not that every ar^2 is in fact equal to every other, but that, in the present state of our knowledge, we have no reason for saying that any of them, or if any which, is greater than any other.

G. W. DE T.

SOUND.

48. *Acoustical Notes.* **Rayleigh.** (Phil. Mag. 2. pp. 280–285, Sept., 1901.) —*Forced Vibrations.*—If free vibrations be represented by cos nt, and if the forced vibration due to a force acting with a very long period be cos pt, then the actual forced vibration will be $n^2/(n^2-p^2)\cos pt$. From this it follows that (1) in all cases the forced vibration takes its period from the force, whatever may be the natural period; (2) for $p < n$, the phase is the same as if the vibration were infinitely slow (the vibrator would be at any instant of time in the position where the momentary force would permanently maintain it); (3) for $n < p$ the phase of the actual vibration is opposite to that defined in (2); (4) if the force have very nearly the period of the free vibrations the effect is much enhanced, even reaching infinity; hence viscous forces must be brought into the reckoning. The author then describes lecture experiments with Thomson galvanometer mirrors to demonstrate these four cases. *Vibrations of Strings.*—The difference in Melde's experiment (tuning-fork, string, pulley, and adjusted weights) between the forced vibrations when the fork works athwart the string, and the vibrations of half the frequency when the fork acts along the length of the string, is demonstrated by illuminating the string by sparks synchronous with the fork: in the former case the string is seen single, in the latter it is seen double. *Beats of sounds led to the two ears separately.*—The results do not exclude the view that the comparatively feeble beats heard may be due to the passage of sound from one ear to the other through the bones of the head, or perhaps through the Eustachian tube. *Loudness of double sounds.*—Beats sound louder than either of the component sounds; according to theory the intensity, which is proportional to the energy propagated, should be, at the loudest, four times as great as either of the components. Two sounds differing by a minor third did not seem louder than either of the components. A. D.

49. *Period of a Rod Vibrating in a Liquid.* **M. I. Northway** and **A. S. Mackenzie.** (Phys. Rev. 13. pp. 145–164, Sept., 1901.)—Historical *résumé*, and discussion. In water the lowering is, within a range of $3\frac{1}{2}$ octaves, independent of the pitch; the lowering for a rod of given cross-section is independent of the length, is approximately the same for brass and steel, and is probably independent of the material, within the range of substances ordinarily used; for a rod of given width it is approximately inversely proportional to the thickness; and for a rod of given thickness it is approximately directly proportional to the width. The effect of viscosity of the liquid is not very marked; but the lowering increases with increased density, the increase not being far from being directly proportional to the added density as compared with water. The authors discuss various formulæ for the lowering-ratio T'/T. A. D.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

50. *Integration of the Equations of Propagation of Electric Waves.* **A. E. H. Love.** (Roy. Soc., Proc. 68. pp. 19–21, March 5, 1901 (Abstract) and Roy. Soc., Phil. Trans. 197. pp. 1–45, July 17, 1901.)—Huygens' principle, which until recently formed the basis for the investigation of wave propagation in the Undulatory Theory of Light, is indefinite, inasmuch as the nature and intensity of the sources of secondary waves are unrestricted, save by the conditions [first postulated by Fresnel] that the secondary waves must combine in advance so as to give rise to the disturbance actually propagated, and must interfere in rear so as to give rise to no disturbance. These conditions are insufficient, and the propagation of light waves is now investigated [this was first done by Kirchhoff] from the system of partial differential equations which they satisfy. This system has the same form both in the theory of an elastic solid ether, emitting transverse waves, and in the electromagnetic theory; the components of the vector quantities involved satisfying, in either case, a partial differential equation of the form $\partial^2\phi/\partial t^2 = C^2\Delta^2\phi$, where C is the velocity of radiation. This equation occurs in the Theory of Sound, and was integrated by Poisson in 1820, but a much more general integral, including that of Poisson as a special case, was obtained by Kirchhoff in 1883, as a solution of the problem of the propagation of luminous waves. The function ϕ, satisfying the equation of propagation, was assumed to have the properties; (1) that outside a given closed surface, S, ϕ, and its first and second differential coefficients with respect to x, y, z, are everywhere finite and continuous; (2) that ϕ vanishes at infinite distances from S. Green's theorem was then applied to ϕ, and to an auxiliary function V which satisfies the equation of propagation at all points except a single point O outside S, and has the form $F(r + Ct)/r$, where F is a function to which suitable properties are assigned.

The vector quantities involved in the equation of propagation are two in number, and, considering the waves as electric disturbances, may be taken to be the electric and the magnetic force respectively. Every one of the vectors in question is circuital, this being the criterion of tranversality of a vector disturbance propagated by wave motion. The circuital condition excludes some of the known particular solutions of the equation, but the anthor obtains a very general system of available particular solutions, from the synthesis of which more general solutions can be obtained. These particular solutions are expressed in terms of spherical harmonics and arbitrary functions of the time. The expression in spherical harmonics is immediately suggested by considering the form of Kirchhoff's function V as corresponding to the solution r^{-1} of the equation $\nabla^2\phi = 0$, and the solutions may be considered as generalisations of those obtained by Lamb in his treatise on Hydrodynamics, from which they differ only in containing arbitrary functions of the time in place of simple harmonic functions. By means of these solutions, two types of sources of electric radiation can be described, the sources of one type being similar to infinitesimal Hertzian vibrators, being related in the same way to an axis, the dependence on time, however, of the emitted radiation being arbitrary. The sources of the second type are

obtained from these by interchanging the *rôles* of the electric and magnetic forces.

The author then proceeds to obtain a more general solution by a method analogous to that employed by Green for the Theory of Potential, the object sought being to express the values of the vectors at a given place and time in terms of their values at other places and times. The first step is the determination of particular solutions which tend to become infinite, in definite ways, in the neighbourhood of chosen points. These are found among the solutions previously obtained. A reciprocal theorem, analogous, in this theory, to that of Green in the Theory of Potential, is then obtained, by a modification of the process by which the equation of propagation is to be obtained from the Action principle, and enables a relation to be established between the values, on any selected surfaces, of two sets of solutions. A modification of Kirchhoff's analysis is then employed to determine the limiting form assumed by this theorem, when the solutions of one system have the assigned character of infinity at a given point. The result arrived at in this manner is that the radiation arriving at a given point may be regarded as due to the distribution of imagined sources of radiation, of the two types previously specified, and having the directions of their axes, and the intensities of the radiation they emit, determined entirely by the values, on the surface, of the vectors involved in the propagation of the waves, upon an arbitrary closed surface, separating the point from all the actual sources of radiation. The general theorem is then applied to the problem of the passage of radiation through an aperture, and, the general problem presenting too great difficulties, it is simplified by the assumptions: (1) that the incident radiation is represented by simple harmonic functions of the time; (2) that the surface is plane. (1) eliminates vector potentials; and (2) is a practically unimportant restriction when the aperture is small. It is then shown that when a train of radiation comes to a perforated screen, or when electric vibrations take place in the dielectric on one side (the nearer side) of a conducting surface, in which there is an aperture, waves are sent out into the medium on the farther side; but the aperture also has the effect of generating a system of standing waves on the nearer side. These systems of waves become, to a great extent, determinate, if we combine with the general theorem the conditions of continuity of the dielectric on the two sides of the aperture. The determination is practically complete when the medium on the nearer side is the dielectric plate of a condenser in which electric vibrations are taking place; and the result can be applied to determine the rate of decay of the vibrations due to transference of the energy to the external dielectric. The example of a condenser with concentric spherical conducting surfaces, the outer conducting sheet being perforated by a small circular aperture, is worked out in detail; and the results suggest that the maintenance of the vibrations depends on the screening action of the outer conductor rather than on the largeness of the capacity of the condenser; in fact, the vibrations of the spherical condenser are much more slowly damped when the capacity of the condenser is small than when it is large, the outer conductor and the aperture remaining the same. G. W. DE T.

51. *Symbolic Integrals of Electromagnetic Equations derived from Initial Conditions.* **L. Silberstein.** (Ann. d. Physik, 6. 2. pp. 373–397, Oct., 1901.)—If ϕ be any operator on x, and $\phi(x)$ denote the result of performing that operation n times in succession, then $f(\phi)$ is an operator having a definite meaning, if at least $f(\phi)$ be expressible in positive integral powers of ϕ, $\cos\phi(x)$, for

instance. In the electromagnetic field we have the two vectors, E, electric force, and M, magnetic force, which satisfy the relations—

$$\frac{dE}{dt} = \frac{1}{AK}\,\text{curl}\,M, \text{and}\,\frac{dM}{dt} = -\frac{1}{A\mu}\,\text{curl}\,E.$$

The conjugate relation here indicated is important.

From these equations, if E_0 and M_0 be given at any point in the field when $t=0$, then, by successive differentiations and eliminations, E_t can be found in the form—

$$E_t = \{\cos(vt\,\text{curl})\}\,E_0 + \left(\frac{\mu}{K}\right)^{\frac{1}{2}}\{\sin(vt\,\text{curl})\}\,M_0 \ldots\ldots\ldots\ldots(A)$$

and M_t in the corresponding manner. Here $\frac{1}{v^2} = A^2\mu K$.

It is shown that these equations, $\cos(vt\,\text{curl})$ and $\sin(vt\,\text{curl})$, satisfy the ordinary trignometrical relations.

Our author next deals with the following difficulty. If E_0 and M_0 are both zero throughout any defined space, then by the above equations they must remain zero for all time throughout that space. And therefore no electromagnetic disturbance can ever travel into it. The proposed solution of the difficulty is that there may be surfaces of discontinuity at which the space differential coefficients, and therefore also the time differential coefficients, of E or M become infinite. Hence the process fails by the failure of Taylor's theorem. He next treats of certain special cases, as for instance that in which E and M are resultants of harmonic vibration.

If D stand for $\frac{d}{dt}$, we have from the fundamental formulæ $\frac{1}{v^2}D^2E = -\,\text{curl}^2E$ or $v^2\,\text{curl}^2 = -D^2$, whence, introducing $i = \sqrt{-1}$, $iD = \pm v\,\text{curl}$, so that D can by this substitution be applied to the initial values E_0 and M_0, otherwise $\frac{dE_0}{dt}$ would have no meaning. When used in this sense, D is written D_s. By substitution in equation (A)—

$$E_t = \{\cos(itD_s)\}\,E_0 \pm \sqrt{\frac{\mu}{K}}\{\sin(itD_s)\}\,M_0,$$

with a corresponding expression for M_t, from which it is shown to follow that—

$$E_t = \{\cos(itD_s)\}\,E_0 + i\,\{\sin(itD_s)\}\,E_0\,;$$

$$M_t = \{\cos(itD_s)\}\,M_0 + i\,\{\sin(itD_s)\}\,M_0.$$

The application of the formula $\epsilon^{i\phi} = \cos\phi + i\sin\phi$ is now evident. If H_t be an operator which converts ψ_0 into ψ_t, H_t satisfies the condition $H_{nt} = (H_t)^n$, whence we are led to $H_t = \epsilon^{tF}$, where F is now an operater independent of t. In the same way if K_R be an operator which converts ψ_P into ψ_Q, P and Q being two points in space, and R the vector PQ, it is shown that $K_{nR} = (K_R)^n$, n being any integer. And this leads to the general form $\psi_{xyz} = \epsilon^{x\frac{d}{dx}}\,\epsilon^{y\frac{d}{dy}}\,\epsilon^{z\frac{d}{dz}}\,\psi_{x=0,y=0,z=0}$. The theory is then extended to the case of imperfect conductors by development of the formula—

$$\mu A^2\{RD^2 + \lambda D\}E = -\,\text{curl}^2E$$

where λ is the conductivity.

S. H. B.

52. *Interpretation of Maxwell's Electromagnetic Equations in Isotropic Media at Rest.* **J. Sauter.** (Ann. d. Physik, 6. 2. pp. 331–338, Oct., 1901.)—The writer assumes a substance, having inertia, and extending continuously through infinite space, and at a given time subject to certain strains. Considering a closed surface S, and a point O on its surface, dS being an element of surface at O, and n_a the direction of the normal measured outwards, the existing stress consists in a force $\mathbf{P}d\mathrm{S}$ acting on dS, and equal to $\mathrm{V}.\mathbf{E}\mathbf{N}_\mathbf{a}$ where $\mathbf{E}$ is a force varying with O and with the time, but independent of n_a, and $\mathbf{N_a}$ is a unit vector in the direction n_a. Hence are derived the principal equations of motion. It is assumed (*a*) that the density at every point is independent of the time; (*b*) that the sudden removal of the constraint at any time would leave the motion uninterrupted without change of the distribution of the velocities in space; (*c*) that initially when $t = -\infty$ the velocity was everywhere zero. From the consideration of this medium the writer passes to that of a medium consisting of discrete particles, each having its centre fixed in space, but capable of turning about an axis through the centre, the orientation of which varies. He obtains a system of equations of the same form as Maxwell's, as generalised by Boltzmann. In this system μ, the density of the author's medium, corresponds to Maxwell's magnetic permeability, the vector $\mathbf{E}$, to the internal electric force, $\mathbf{B}$ (or $_\mu\mathbf{H}$) to the magnetic induction, $\mathbf{H}$ to the magnetic force. Also $\mathbf{D}$, which, in the author's mechanical theory, is the inclination of the axis of a particle to its position of equilibrium, corresponds to Maxwell's electric displacement. S. H. B.

53. *Poynting's Theorem.* **W. S. Franklin.** (Phys. Rev. 13. pp. 165–181, Sept., 1901.)—A series of papers by P. S. Wedell-Wedellsborg [see Abstracts Nos. 136 (1898), 96 and 1831 (1900)] criticising Maxwell's equations in general, and Poynting's theorem in particular, suggested the supplementing of Poynting's original discussion in some particulars. Poynting's theorem is a necessary consequence of Maxwell's equations, and therefore must hold good if they are true, and the author considers that an understanding of the theorem and the conviction of its truth can only be obtained through these equations. The theorem asserts that the energy stream is, at any point, perpendicular both to the electric and magnetic fields, and that the amount of energy which in one second streams across an area of 1 sq. cm. at right angles to the stream is equal to $1/8\pi$. EH, where E is the electric field intensity, and H is that of the magnetic field. J. J. Thomson has pointed out (Recent Researches, p. 313) that, although Poynting's expression for the energy stream is perhaps the simplest expression that will satisfy the conditions, it is not the only one, since any energy flow which has no convergence may be superposed upon the Poynting stream without changing the distribution of energy.

Much of the criticism has been directed against Poynting's examples. Now an example of the theorem is necessarily a solution of Maxwell's equations for a particular case. This requires a complete knowledge of the boundary conditions and of all singularities within the region, which makes a solution for any ordinary current generator and its circuit quite impracticable. Wedellsborg's earlier criticisms were satisfactorily met by D. A. Goldhammer (Zeitschr. Phys. Chem. 23. p. 686, 1897), and these, and also his later ones, by Scheye [see Abstracts Nos. 1237 (1898) and 848 (1900)]. G. Mie [see Abstract No. 2438 (1900)] has well met the need of a numerical solution of Maxwell's equations for a particular case involving the flow of energy into a conductor. In Scheye's last-mentioned paper he agrees with Wedellsborg's contention that the electric field distributions required by Maxwell's equations do not agree

with experiment, in so far as to admit that further decisive experiments are required. The author does not agree with this admission. The electric field intensity at a point where the current density is i, of a homogeneous conductor of specific resistance r, is ri. Therefore, if the current is steady, r being constant, ri can have no convergence, and there is therefore no free charge in the interior; also, near the boundary of the conductor, i, and therefore also the electric field, is parallel to the surface. The field distribution outside depends on conditions that, at each point of the surface of the current conductor, the tangential component of the external field should be equal, both in magnitude and direction, to the value of ri inside the surface; and that at each point of the surfaces of other conductors in the region the tangential component must vanish. The electric lines of force are therefore never quite normal to the surface of a conductor carrying current, but may in special cases be parallel to it.

With regard to the experimental evidence, Ohm's law shows that the potential gradient parallel to a wire is equal to ri, and this law is verified by a great mass of experimental evidence. On the other hand, the so-called capacity effects on long transmission lines and in submarine cables are due immediately to the component of the electric field at right angles to the surface of the conductors; all practical calculations of these capacity effects are based directly or indirectly on Maxwell's equations, and these calculations agree with experiments as closely as could be expected, considering that the calculations are mostly only approximations, and are usually based upon hypothetically simplified data for the dielectrics and magnetic substances experimented with. The author considers that the submarine cable tests by Crehore and Squier [see Abstract No. 1969 (1900)] constitute the most complete experimental verification hitherto published of the theory of the electric circuit involving both electric and magnetic energy. He calls attention to the fact that for short circuits the electrical energy is negligible in comparison with the magnetic energy, while for extended ones, such as long transmission lines, the former may even exceed the latter in amount. The paper concludes with some instructive and interesting particular solutions of Maxwell's equations, illustrative of Poynting's theorem, selected for their simplicity and for their capacity of representation in two dimensions, so that the accompanying diagrams represent the solutions completely. G. W. DE T.

54. *Rowland's Experiment.* **A. Eichenwald.** (Phys. Zeitschr. 2. pp. 703–704, Sept. 7, 1901.)—In view of Crémieu's earlier work, the author has repeated Rowland's experiment on the magnetic effect of convection of electric charges, and has obtained results which quantitatively confirm Rowland's. A. D.

55. *Electric Field Produced by Magnetic Variations.* **V. Crémieu.** (Annal. Chim. Phys. 24. pp. 85–118, Sept., 1901.)—After an historical introduction the author shows that a change rate $d\phi/dt$ in the magnetic flux should give rise to a ponderomotive force $f = m/2\pi r \cdot d\phi/dt$. Experiments undertaken to confirm this are described, with the precautions observed, but the results were entirely negative. A. D.

56. *Magnetic Effect of Electric Convection.* **V. Crémieu.** (Annal. Chim. Phys. 24. pp. 145–204, Oct., 1901.)—The paper contains a description and critical discussion of the experiments of Rowland (Amer. J. Sci. xv. p. 30, 1878; positive results), Lecher (negative), Himstedt (positive), Rowland and

Hutchinson (Phil. Maga. xxvii. 445, 1899; positive results). In all these researches the measuring apparatus was placed in a region which was the seat of perturbations of all sorts; the deviations obtained were too feeble, and were of the same order as those due to these perturbations; and the precautions taken to ensure that the charge of the disc was really carried round were insufficient. The author devised apparatus to get over these difficulties, brusquely creating a convection current and observing its effect upon a neighbouring induction circuit, with a control by an adjusted circuit-current of calculated strength. The practical difficulties met with are described, and their solution. The results arrived at are that where, for example, the deviation of the light spot should have been at least 37 mm. in a given direction, the maximum deviation obtained was 7 mm. on one side or the other of the zero, apparently accidentally; while the control-current of calculated strength gave, with the apparatus in use, exactly the calculated deviation, always in the proper direction. Further experiments are described, which were made in view of discussions with Pellat, Carvallo, Poincaré, and Blondlot, but the author still obtains only negative results. A. D.

57. *Particulars of Damage Caused by Lightning.* **F. Neesen.** (Elektrotechn. Zeitschr. 22. pp. 991–993, Nov. 28, 1901.)—In this paper there are given particulars of the damage done to three sheds in the gunpowder works at Wahn, and also of the lightning conductors thereon; similar particulars are also given relating to the overhead system of the Berlin Street Railway. C. K. F.

DISCHARGE AND OSCILLATIONS.

58. *Emanations of Phosphorus.* **C. Barus.** (Phil. Mag. 2. pp. 391–403, Oct., 1901.)—The third of a series of papers [see Abstract Nos. 1669 and 2204 (1901)]. The present experiments relate to the apparent decay, with lapse of time, of the ionisation produced by phosphorus emanation between the plates of a condenser, for fixed distances between the condenser-plates, and to the transmission of the ionisation through layers of air and other media. The author concludes that it is improbable that the rate of production of ions by the phosphorus diminishes with lapse of time, and that the decrease of conductivity is more probably due to fluctuations of temperature and similar incidental causes. The author next proceeds to find mathematically the change in the number of ions per cubic centimetre with change of the distance between the condenser-plates. Experiments made to ascertain whether the ionised particles exhaled by phosphorus are accompanied by some form of obscure radiation gave results against the existence of such radiation. The emanation is stopped by non-porous media, however thin. Other experiments described show the effect of sulphuric acid and of ammonia polysulphide, when used in place of phosphorus as "dust" producers. W. C. H.

59. *Simultaneous Volumetric and Electric Graduation of Steam-tube with Phosphorus Ioniser.* **C. Barus.** (Phil. Mag. 2. pp. 477–488, Nov., 1901.)—A continuation of the author's investigations on ionised phosphorus emanation. The current of air passes through a tubular condenser before entering the colour tube, and the current in the condenser is measured simultaneously with observation of the volume of air passing. As no change takes place in the colour-tube when the condenser is charged or discharged, it is evident

that only an insignificant number of the nuclei present take part in the radial convection of electricity across the condenser; but, on the other hand, the current varies with the number of nuclei present. Tables of results and curves are given, and the author enters into a mathematical discussion of his results. [See further Abstract No. 2204 (1901).] W. C. H.

60. *Effect of Temperature and of Moisture on Emanation of Phosphorus, and Distinction in Behaviour of Nuclei and of Ions.* **C. Barus.** (Amer. Journ. Sci., 12. pp. 327–346, Nov., 1901.)—These experiments form a continuation of the author's earlier work on phosphorus emanation [see Abstracts Nos. 1309 and 1669 (1901)]. They show that nuclei adapted to condense atmospheric moisture are produced most abundantly at about 13° C. Below this temperature the condensational activity falls off very rapidly, while above 13° it decreases slowly with rise of temperature, having lost only 25 per cent. of its value at 35°. On the other hand, the ionisation of air passing over phosphorus increases with temperature to a maximum at about 20°, declining thereafter slowly. These results may be accounted for if ionisation is a result of dissociation of nuclei, so that up to a certain point ionisation would increase as condensational activity decreases.

If the phosphorus is not quite dry to begin with, permanent electrical conduction is produced in the condenser, which does not appear when the phosphorus has been thoroughly dried in a dessicator. As the electrical conduction produced is quite out of proportion to the amount of moisture present in the phosphorus, the author thinks it probable that the emanation escapes in some combination with the moisture. If freshly cut fuming phosphorus be used in the ioniser, the currents in the condenser may be raised to nearly twice their usual value. Thus the low concentrations formerly found by the author for the tubular condensers (2×10^4 nuclei per c.c.) have been made more nearly to approach the value found from plate and spherical condensers (4×10^4). W. C. H.

61. *Analogies in Electric Flow in Gases and Nernst Filaments.* **W. Kaufmann.** (Gessell. Wiss. Göttingen, Nachr. Math.-Phys. Klasse, 1. pp. 62–73, 1901.)—The author shows, from observations of the e.m.f. and current strength in a rod of the Nernst earth placed in an electrically heated oven, that all the phenomena characteristic of discharge through gases are exhibited in discharge through the Nernst earth. Determinations were made at temperatures of 348°·5 C., 366°·5 C., and 397°·5 C. Intermittent discharge was obtained at a temperature of 308°–318° C.; the discharge period (which varied from 20 to 50 seconds) was somewhat irregular, on account of a retardation of the same character as that observed in the case of discharge through gases. The phenomena are due, according to the author, to rapid diminution of resistance with increase of temperature. D. H. J.

62. *Effect of Inserted Bodies in an Electric Discharge.* **M. Toepler.** (Ann. d. Physik, b. 2. pp. 339–346, Oct., 1901.)—Using one of his own influence-machines of several plates, the author tries the effect of—(1) glass plates pierced with small holes; (2) small metal bodies in the line of discharge between the poles. The colour effects in the several cases of glow, brushes, and sparks are set forth. The conclusion reached is that, when the discharge is increasing, a row of more or less well-coloured patches of light is always to be seen in it. P. E. S.

63. *Electric Discharges from Points.* **F. Tamm.** (Ann. d. Physik, 6. 2. pp. 259–279, Oct., 1901.)—Experiments were made to test the effect of different air pressures on the rate of discharge of static electricity from points. The result is found capable of representation by a formula. The effect of moisture of the air is also dealt with, and the results tabulated.

E. H. B.

64. *Inconstancy of Spark Potential.* **K. R. Johnson.** (Ann. d. Physik, 5. 1. pp. 121–135, 1901.)—The spark discharge is discussed in several of its bearings. Referring to the Wollaston experiment cited in a previous paper [see Abstract No. 631 (1901)], the production of an H and O mixture, Knall gas, at the electrodes of a water cell placed in the secondary circuit of an induction coil, is a result of the oscillations which are set up at break. The presence of these oscillations has also been demonstrated by the Braun tube. When the Wollaston cell is placed in the secondary of a Tesla transformer, the production of the gas is accompanied by faint sparks, the gas evolution and the sparks gradually disappearing as the water is acidified. The effect of the acid is to increase the liquid's conductivity, and thereby to reduce the momentary potential gradient. When the rise of potential at either electrode becomes great enough, the electrode becomes coated with a layer of gas, which stops the electric flow, and the p.d. between electrode and electrolyte becomes great enough to cause a spark. A Hertz resonator failed to produce the gas mixture. This is put down to the high frequency of the oscillations employed combined with the lagging of the electrolyte potential behind that of the electrode. To amplify the explanation of discharge conditions, the gas in the spark-gap is compared to a wall on which an enclosed gas exerts a pressure, the wall collapsing when the pressure reaches a certain value. The electric pressure required to break down the dielectric is, by following out the analogy, proportional to the number of collisions on the wall, *i.e.*, to the frequency of the oscillations, the reduction of the *vis viva* of the molecules corresponding to the damping of the oscillations. An ideal case is considered where the electrodes are connected by a metal in which a periodic current i is flowing such that, $i = i_0 \sin \beta t$, and the potential $V = E_1 - E_0 \cos(\beta t - \phi)$, there being no damping. Taking the *vis viva* of each collision as $(Vi)_{max}$ and the electric pressure as $\frac{\beta}{2\pi}(Vi)_{max}$, where $\frac{\beta}{2\pi}$ is the frequency of the oscillations, the specific strength of the gap is denoted by b, so that for a spark-gap of length λ, $b\lambda = \frac{\beta}{2\pi}(Vi)_{max}$.

In the first case considered, where E_0 is supposed very small compared with E, and κ is written for $1/b$, the expression is reduced to—

$$\lambda = \frac{\kappa\beta i_0}{2\pi}(E - E_0 \sin \phi).$$

In the second case $E = 0$, and the expression for the length of gap becomes—

$$\lambda = \frac{\kappa\beta i_0 E_0}{2}$$

approximately. When a spark is passed across a gap in parallel with a condenser of large capacity a considerable p.d. is required. After discharge, the change in the potentials of the knobs gives rise to somewhat powerful oscillations. This is Helmholtz's "good spark." If the radius of the spark knob, at first large, is reduced, its capacity sinks also, and the frequency of the vibrations increases. It follows from the first expression for λ that the

p.d. necessary for a discharge diminishes, so that, after a certain point, the sparks pass across almost continuously, being unbroken to the eye, and a silent discharge is thus obtained. Finally, some irregularities, *e.g.*, those caused by blowing the spark, are considered. G. E. A.

65. *Photoelectric Effect near Sparking Potential.* **H. Kreusler.** (Ann. d. Physik, 6. 2. pp. 398–411, Oct., 1901.)—Hertz's observation that ultra-violet light affects spark discharges, through a shortening of the procrastination period (Warburg), in a manner independent of the material (iron being by exception specially sensitive), stands in a certain sense in opposition to Hallwachs' effect, the dispersion of negative charges under ultra-violet light in a manner which depends very much upon the material, iron being in this case specially insensitive. The more anodic the metal, the more readily, as a rule, is Hallwachs' effect produced : Rb has a maximum effect in the yellow, K in the blue ; heavy metals require ultra-violet light. If both these effects are due to the same cause, it might be that metals of low sensitivity at low potentials were sensitive at high potentials ; and this is found to be the case, the differences in the Hallwachs effect under conditions approximating to those of Hertz's phenomenon being very small as between different metals. A. D.

66. *Photoelectric Currents Applied to Ultra-violet Photometry.* **H. Kreusler.** (Ann. d. Physik, 6. 2. pp. 412–423, Oct., 1901.)—The great intensity of the photoelectric effect [see preceding Abstract] near the sparking potential points out an extremely delicate test for ultra-violet rays ; and a method is described of applying this to quantitative work. A. D.

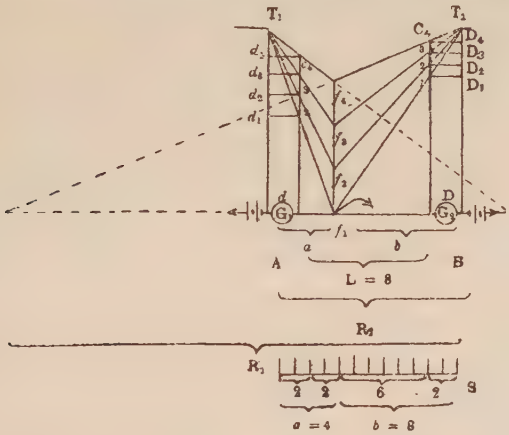
67. *Electric Overtones.* **Lamotte.** (Journ. de Physique, 10. pp. 589–597, Oct., 1901. Also Annal. Chim. Phys. 24. pp. 205–287, Oct., 1901.)—After reviewing the work of others, and the arguments for and against the existence of electric oscillations of higher orders along wires, the author describes his own experiments in the same direction. His final conclusions from these are as follows :—In studying electric waves propagated along wires proceeding from one of the ordinary oscillators, such as the Lecher, Blondlot, or Blondlot-Drude, one observes waves of different periods, their number being greater as the system is made longer. Among these waves one can distinguish two groups—those whose periods are comparable to the period proper to the primary, and those whose periods are comparable to that proper to the secondary. In each of the groups the lengths of the waves form a set which tends more and more towards a harmonic series as the length of the vibrating system increases. By suitably arranging the experimental conditions the harmonic series may be complete or contain the odd terms only. The observed results render it probable that in a Hertzian oscillator multiple vibrations are present forming a quasi-harmonic series. The theory of Bjerknes would then apply separately to such a couple, formed by one of these vibrations and that vibration of the resonator of comparable period. This view is, however, only hypothetical and needs confirmation. E. H. B.

68. *Influence of Electrical Waves on Chemical Action.* **F. Lengfeld** and **J. H. Ransom.** (Journ. Phys. Chem. 5. p. 502, Oct., 1901.)—Exposure for forty-eight hours to electrical waves 300 metres long did not lead to any reaction occurring between hydrogen and chlorine, or hydrogen and oxygen. W. E. T.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

69. *Graphic Proof of the Betts Test.* **E. Raymond-Barker.** (Elect. Rev. 49. pp. 420–422, Sept. 13, 1901.)—Betts' test was treated of in Abstract No. 1684 (1901). Similarity to that of Wilbrant referred to by the writer in the Elect. Rev. of Nov. 21, 1890, is pointed out. His graphic demonstration is as follows :—

Deflections d and D on G_1 and G_2, at stations A and B, are respectively inversely proportional to the resistances a and b, also to the *apparent* resist-



ances R_1 and R_2 due to the mutual opposition of the currents from the two cable ends at which the p.d.'s are respectively the perpendiculars T_1 and T_2.

The accompanying figure shows a simple case where the resistance of each of the galvanometers G_1 and G_2, at stations A and B, is equal to that of one-quarter the length of a cable conductor bisected by the fault in the relative proportion of 1 to 3. Four different conditions at the fault are shown, viz. :—

f_1 Fault making dead earth.
f_2 „ with resistance to earth giving potential f_1 f_2.
f_3 „ „ „ „ f_1 f_3.
f_4 „ „ „ „ f_1 f_4.

The following table summarises the accompanying conditions :—

Ex.	P.D. at fault.	Right angle triangle representing deflection on G_1	Right angle triangle representing deflection on G_2	Inverse proportions relative to deflections and actual resistances, *i.e.*, deflections inversely proportional to resistances. (Resistances) (Deflections) (Ratio)
1	*nil*	$T_1 d_1 c_1$	$T_2 D_1 C_1$	$b : a :: T_1d_1 : T_2D_1 = 2 : 1$
2	$f_1 f_2$	$T_1 d_2 c_2$	$T_2 D_2 C_2$	$b : a :: T_1d_2 : T_2D_2 = 2 : 1$
3	$f_1 f_3$	$T_1 d_3 c_3$	$T_2 D_3 C_3$	$b : a :: T_1d_3 : T_2D_3 = 2 : 1$
4	$f_1 f_4$	$T_1 d_4 c_4$	$T_2 D_4 C_4$	$b : a :: T_1d_4 : T_2D_4 = 2 : 1$

The *apparent* resistances when the p.d. at the fault is f_1 f_4 are shown in the diagram, viz., R_1 and R_2, and here again the inverse proportion obtains, viz. :—

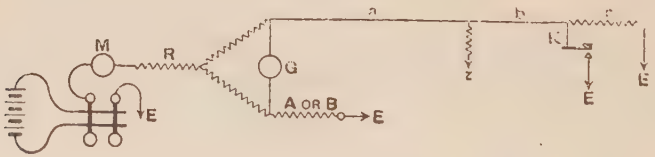
$$R_2 : R_1 :: T_1d_4 : T_2D_4 :: 2 : 1.$$

The *apparent* resistances accompanying the other three conditions are not indicated, but they may readily be obtained by continuing to the common resistance base the lines $T_1 - f_3, f_2, f_1$, and $T_2 - f_3, f_2, f_1$.

The author suggests the tests being taken when earth currents are *nil* or nearly so, which normally occurs in Atlantic cables four times in the twenty-four hours. E. O. W.

70. *Modified Blavier Test.* **W. J. Murphy.** (Electrician, 47. pp. 953–954, Oct. 11, 1901.)—The Blavier test is only reliable when the resistance of the fault is somewhere about that of the line beyond it, and when testing currents are adjusted to maintain a constant flow through the fault throughout the test. Instead of earthing the cable during one stage of the test and keeping it free during another, the author adds resistance to the cable, and permanently earths the end of that resistance, connecting also an earthing key at the junction of the resistance and the line.

The arrangements are shown in the accompanying diagram, where M is a milliammeter, R an adjustable resistance, r a resistance at the distant end equal in amount to about half that of the section of line b. Then if L is the resistance of the fault, let $A = a + bz/(b + z)$ and $B = a + (b + r)\,L/(b + r + z)$. The key, K,



is to be depressed and raised every alternate minute for, say, ten minutes. With K down, adjust the testing current to as high a value as the fault will stand without showing unsteadiness. Observe the earth current *after* the testing current has been on, and balance to it to obtain A. With K raised reduce the testing current to 0·75 of its previous value if z is anything like the value of b, or to 0·5 of its previous value if z is very high (over twenty times b), and after applying the battery for a few seconds observe the current to earth, and again obtain a balance for B. Having verified A and B by second readings, adjust the currents more closely for the remaining observations, making $C_B = C_A \frac{A - a}{B - a}$, for constant potential at the fault. Use zinc to line only. The receiving instrument may be kept in circuit either as r or as a part of r. E. O. W

71. *Conductivity under varied E.M.F.* **J. C. Bose.** (Electrician, 47. pp. 830–832, Sept. 20, and pp. 877–881, Sept. 27, 1901. Paper read before the British Association.)—Both simple and complex contacts were used. The conductivity of a contact is found to increase with increasing e.m.f. These changes are shown in a series of curves under varying conditions of contact and e.m.f. Cases are shown of the increase in conductivity, followed by recovery, when flashes of radiation fall on the contact. P. E. S.

72. *Dielectrics.* **M. v. Hoor.** (Elektrotechn. Zeitschr. 22. pp. 716–719, Sept. 5; 749–751, Sept. 12; and pp. 781–785, Sept. 19, 1901. Extract from a paper read before the Hungarian Academy of Science, May 20, 1901. [See also Abstract No. 1113 (1901).])—The second article contains the results of experi-

ments made to find the variation of the dielectric constant with the slope of potential for paper, paraffin, guttapercha, glass, and micanite. The author prepared a large number of paper condensers impregnated with various paraffins, and found that very slight differences in the mode of construction and in the materials used quite altered their dielectric properties. The results are summarised in the following table, in which the lowest and highest values are given :—

Condenser.	Surface of Plates in sq. cm.	Thickness of Dielectric in cm.	Volts per cm.	Capacity m.f.	Dielectric Constant.
Paraffined paper.....	129,300	0·007	55·500	5·97	3·65
			0·528	6·01	3·68
Do.	12,930	0·007	54·400	0·529	3 236
			2·520	0·55	3·365
Felten and Guilleaume 500-volt concentric paper cable, diam. of core 1·38 cm., length 818 metres		0·22	7·480	0·045	2·75
			0·910	0·280	17·12
Crown Glass I.	1,440	0·035	22·900	0·021	10·7
			4·460	0·0251	12·8
Crown Glass II.	12,600	0·0193	27·200	0·40	6·92
			1·037	0·417	7·22
Megohmit.....	50,600	0·21	5·950	0·1085	5 09
			0·286	0·113	5·31
Guttapercha.....	106,000	0 0122	41·000	2·42	3·155
			0·491	2·50	3·26

The crown-glass condenser No. I. was made by the author. The plates were washed in ether, heated very slowly to 100° and cooled very slowly, and the whole condenser immersed in oil under a vacuum. The crown-glass condenser No. II. was made by Mengarini with silver-foil ; the condenser when built up was heated in a muffle to the melting-point of the glass, so that the edges of the glass plates beyond the silver fused together. It may be seen from the table that paraffined paper shows practically no change in dielectric constant with the slope of potential ; megohmit and guttapercha show small changes, glass considerably more, while the Felten and Guilleaume paper-insulated cable shows an enormous change, the dielectric constant increasing almost as the slope of potential diminishes. A mica condenser by Elliott Brothers showed no change in the dielectric constant between 5 and 100 volts ; the influence of the time of charge was negligible, and the temperature coefficient very small.

The third article deals with the polarisation of the various dielectrics already dealt with, and numerous curves are given for each dielectric at different potentials between the time of charge and the charge. In the paraffined paper condensers the charge increased only some 3 per cent. between 5 and 30 seconds, and at higher potentials only 0·2 per cent. ; the discharge was almost complete in 3 seconds. The Felten and Guilleaume cable gave similar results. In the glass condensers the time of charge was far longer, and increased with the potential. In the megohmit condenser it was also long, but diminished with the potential. The difference in the quantities at charge and discharge was small, 2 per cent. at most in the

paraffined paper and megohmit condensers, but reached 6 per cent. in the glass condensers.

The last article deals with the energy absorbed in the polarisation period, reckoned from an interval of 5 seconds after commencing the charge. The curve of current and time was taken by a well-damped galvanometer, till the current reached a constant value representing the leakage current of the condenser. The curve was integrated up to this point from the period of five seconds, excluding the constant-leakage current. The result multiplied by the potential was taken as the polarisation energy. The curves of current and polarisation energy with time of charge are given for the various condensers. The following table gives a summary of the results. The column headed "Charge Energy" gives the energy (reckoned from observations with a ballistic galvanometer) in the charge during 5 seconds; the following column gives the ratio of the polarisation to the charge energy. The column headed "Ohmic Energy" gives the energy lost in leakage. The energy is expressed in ergs per cubic cm. of dielectric.

Condenser.	Volts per cm.	Time of Polarisation. Seconds.	Insulation Resistance. Megohms.	Ohmic Energy.	Polarisation Energy.	Charge Energy.	Ratio.
Megohmit	618	200	4,670	0·44	0·94	0·86	1·09
	1,860	220	5,730	5·49	8·12	7·80	1·145
	3,700	140	5,720	13·92	30·10	31·3	0·962
Paraffined Paper	18,400	120	6,820	32·30	8·86	485·0	0·0182
	46,200	130	6,920	216 0	75·3	305 0	0·0247
Crown Glass No. I.	1,980	120	1,970	106·8	28·65	18·57	1·54
	5,980	90	1,930	751·0	99·20	169·5	0·585
	12,000	100	1,545	419·0	676·	680 0	0 993
Cable	1,470	80	69,800	0·133	0·184	3·19	0·0527
Guttapercha	8,680	230	1,260	15·8	16·8	106·4	0·158
	18,000	210	945	83·3	61·0	458·0	0·133
Crown Glass No. II.	3,350	600	2	102000	24300	32·3	750

The table shows that the polarisation energy varies from 2 per cent. to 100 per cent. of the charge energy, except in the case of the glass condensers, in one of which it is 750 times the charge energy. The author could find no general law connecting the polarisation energy with the charging potential; assuming it to vary as V^n, n varied from 1·7 to 2·2 in the different condensers. The author is occupied in experiments on the effect of the thickness of dielectric on the polarisation phenomenon, but in the present article only states that this has a marked effect on the form of the discharge curve, the amount of the polarisation energy, and on the loss of energy due to hysteresis.

G. H. B.

73. *Insulation Resistance.* **A. W. Ashton.** (Phil. Mag. 2. pp. 501–523, Nov., 1901. Paper read before the Physical Society of London, May 31, 1901.)—Confirmation was obtained of Heims' result (Electrician, 25, p. 751, 1890), that a deviation from Ohm's law occurs with cable dielectrics, viz., by giving a greater conductivity with higher pressures on a given thickness. Similar results were given by A. Siemens (Inst. Elect. Engin., Journ. vol. 19, 1890) for rubber, fibre, and guttapercha cables for voltages from 145 to 17,500 volts, and by Leick [see Abstract No. 298 (1899)] for guttapercha, paraffin, and sulphur; but all these tests were made after only a few minutes' electrification. Pure sheet Para rubber, pure rubber (origin other than Para), vulcanised rubber, paraffined paper, and mica were found by the author to deviate from Ohm's law after such electrification that the steady state was reached. Okonite (apparently a vulcanised rubber compound, composition not given) never reached the steady state. The discharge current c varied with the time t according to the curve $\log c = -8{\cdot}060 - 0{\cdot}343 \log t$, for the particular okonite cable tested, viz., $\frac{3}{18}$, covered to an outside diameter of 0·208 inch and 2,760 feet long. Experiments on a paraffin paper condenser and the above okonite cable show that the charging current varies with time according to the formula $C - C_0 = At^{-x}$ where C is the charging current, A and x are constants, and t is the time in seconds since electrification commenced. When t is very great, $t^{-x} = 0$, and the current becomes constant and $= C_0$. This may, therefore, be a current due to true conduction, while the variable part At^{-x} may represent the energy which is slowly absorbed by the condenser; the ratio of the charging pressure to C_0 is the true resistance. C_0 could not be obtained for okonite, but the author concludes—(1) That the current during the first hours of electrification increases when the pressure is increased [more rapidly than proportionally to the pressure]; (2) that this does not necessarily prove the okonite not to follow Ohm's law, as the true conduction current C_0 must be less than the total current unless electrification is continued for very long periods; (3) that the charging current is a power function of the time, and on this may be superposed the true conduction current. Other experiments were made which showed that the only deterioration in rubber due to moderate alternating pressures (2,400 volts) was in the case of pure Para, and due to ozone, or other gases generated by alternating stress, attacking the rubber. Breakdowns generally occurred at the edges of the sheets of tin-foil.
M. O G.

74. *Dielectric Strain.* **L. T. More.** (Phil. Mag. 2. pp. 527–531, Nov., 1901.)—More here replies to Sacerdote, justifying the accuracy of his own method and apparatus, and discussing the results of Quincke, Cantone, and Sacerdote. The evidence as to the existence of any elongation of glass tubes when electrically charged is very conflicting, and, by reason of probable errors, doubtful. The tube tends to bend by electrostatic attraction; the elongations are too close to the limits of the apparatus to establish a law when the existence of the effect is in doubt; the change of length on charging is quite different from that on discharging, and the difference is erratic; and the greater the precautions taken against errors and extraneous effects, the less the amount of the elongation. [See also Abstracts Nos. 2440 (1900) and 1320 (1901).]
A. D.

75. *Galvanometer of High Sensibility.* **C. E. Mendenhall** and **C. W. Waidner.** (Amer. Journ. Sci. 12. pp. 249–262, Oct., 1901.)—The authors describe, with scale diagrams, a Thomson galvanometer, presenting new

features in certain details. The paper, however, deals chiefly with experiments on galvanometer magnets, made to determine their best size, shape, and material. The magnetic moments of the small magnets were measured by mounting them on small brass discs, and oscillating them in vacuo. The following are the results obtained : The limiting intensity of magnetisation is reached in a field of 1,000. For short magnets the magnetic moment decreases more rapidly than in proportion to the length. The intensity of magnetisation increases as the cross-section of the magnets ; this means that there would be a gain in sensibility by using several small magnets over one of their united cross-section, provided, however, that the magnets are not greatly weakened by their mutual action. Measurements made to determine this latter question showed only a small weakening due to mutual action, of about 5 per cent., when the magnets were 1 mm. apart, increasing to 19 per cent. when they were in contact. As regards the quality of steel, watch hair-spring was found to be the best material, after a special magnet steel, probably tungsten steel, which gave moments 25 per cent. greater. The effect of jars or shocks on the magnetic moment is negligible ; boiling in water reduces it by 10 per cent. to 15 per cent., most of this loss occurring in the first few minutes of boiling. The sensibility of a galvanometer increases with the ratio of magnetic moment to moment of inertia, and Paschen showed that the sensibility increased inversely as the square of the length of the magnet ; making allowance for the fact that the magnetic moment is not proportional to the length, the authors show that the sensibility increases more nearly as the length diminishes. Further, taking into account the moment of inertia of the non-magnetic material of the system, they show that a maximum sensibility is reached for magnets of a certain length, which, in a particular case considered, was found to be 1·1 mm.

The paper concludes with a table giving the constants of the most sensitive galvanometers made. That constructed by the authors gives 6,090 mm. deflection per microampere at 1 metre with a period of 10 seconds and resistance of 1 ohm. G. H. B.

76. *Hot-wire Ammeters and Voltmeters.* **A. Soulier.** (Ind. Élect. 10. pp. 474–476, Oct. 25, 1901.)—The article describes the hot-wire instruments made by Chauvin and Arnoux. They are provided with a compensating device for variations of outside temperature. The ammeters consist of a low-resistance voltmeter, giving full deflection for 0·15 volt, and a shunt of material with low temperature coefficient. The shunts are all interchangeable. G. H. B.

77. *New Form of Potentiometer.* **P. Heyck.** (Elektrotechn. Zeitschr. 22. pp. 871–874, Oct. 17, 1901.)—This is a description of an improved type of compensation apparatus designed by Professor Thiermann, and in use in the standardising-room of the Hanover Technical High School. Measurements of voltages from 0·001 to 1,000 can be made with it, with an accuracy of 0·1 per cent. A Weston cell is used as a standard, and its e.m.f. can be balanced against any other by a series of resistances arranged in dials. The apparatus can also be used as a Wheatstone Bridge. Diagrams of connections and photographs are given. W. W. H. G.

78. *Mercury Jet Interrupter.* **R. H. Cunningham.** (Elect. World and Engineer, 38. pp. 588–589, Oct. 12, 1901.)—The paper describes a new form of mercury jet interrupter for induction coils, to be driven by an electric motor. The mercury issues under centrifugal force from two tubular arms, and is raised again from the well by an archimedian screw. G. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

79. *Fallacies Connected with some Recent Alternating-Current Inventions.* **P. Bunet.** (Ind. Élect. 10. pp. 472–474, Oct. 25, 1901.)—A number of recent patents which have come under the author's notice appear to be based on the following fallacy: "Imagine a gramme ring with a commutator, and suppose that by applying brushes to various points of the commutator a system of polyphase currents is supplied to the winding, the angular distances between the different brushes corresponding to the phase-differences between the currents. A rotating magnetic field will thereby be produced, and as this sweeps across the conductors it gives rise to a reactance e.m.f. But now suppose that the ring itself is rotated synchronously in the direction of the field, or that while the ring is stationary the brushes are rotated in a direction opposed to the rotation of the field; then the field will become stationary with respect to the windings, and hence the reactance e.m.f. will disappear, the ring behaving to each current as if it had resistance only." The author exposes the fallacy of this reasoning, and shows that such rotation, so far from suppressing the reactance e.m.f., would only give rise to further trouble on account of the violent sparking at the brushes. A. H.

80. *Effects Produced by Alternating Currents in Ring Armatures.* **M. Leblanc.** (Écl. Électr. 29. pp. 113–117, Oct. 26, 1901.)—The author criticises deductions sometimes drawn from the theorem that it is possible with alternating currents of frequency f to produce a nearly steady magnetic flux in a ring armature by the simple expedient of making the brushes rotate backwards round the commutator with an angular velocity $2\pi f$. It is erroneously deduced, for example, that since the flux is constant the applied p.d. has only to overcome the ohmic resistance of the windings of the armature. He points out that at any instant the coils between consecutive brushes act like the primary windings of a polyphase transformer on the coil or coils short-circuited by the brushes. The currents in these short-circuited coils are, comparatively speaking, small, and hence there is a decided phase-difference between the applied p.d. and the current in the coils between consecutive brushes. He concludes that if we send n polyphase currents through a ring armature by means of n brushes separated from one another by angles $\frac{2\pi}{n}$ then the counter e.m.f.'s developed between the brushes which determine the magnitude of the currents in the coils are exactly the same, whether the brushes are fixed, or whether they rotate round the commutator. He gives quotations from a paper of his own published in the Comptes Rendus for July 29, 1889, showing that he then realised the importance of the applications of the use of a ring armature with alternating currents. A. R.

81. *König's Manometric Flames for Studying Changes in Wave-form of Alternating Current.* **R. Weber.** (Ann. d. Physik, 6. 3. pp. 565–569, Nov., 1901.)—The membrane of the chamber through which the gas passes on its way to the burner carries in its centre a short soft-iron cylinder, 1 cm. in diameter and 0·2 cm. long. This is placed in front of the laminated core of an electromagnet, whose coil is 5 cm. long and wound with 3,000 turns of fine wire to a resistance of 280 ohms. The laminated core is polarised by being placed in contact with one end of a permanent bar magnet 25 cm. long. The flame is viewed in a rotating mirror. The method does not give the

actual wave-shape, but changes in the wave-shape may by its aid be rendered visible. Specimens are given of several flame-pictures corresponding to different wave-shapes. A. H.

82. *Phase-swinging and Theory of Damping Coils.* **W. M. Thornton.** (Electrician, 47. pp. 870–872, Sept. 27, and pp. 914–916, Oct. 4, 1901.)—The author plots a polar diagram in which the vectorial angle represents the angle of phase-difference, and the radius vector the power (or the torque, to a different scale). He then shows that an elementary arc of the curve so obtained represents the work done during a slow change from the one phase angle to the other, when the variation of load is gradual. If, on the other hand, the change of load is sudden, the work done during the rapid change of phase is greater, the additional amount of energy being supplied by the kinetic energy of the armature. Oscillations are thereby set up. Assuming that there is no damping, the author writes down the differential equation corresponding to the oscillations, and finds the period. He next considers the more complicated case in which damping coils are used, taking first the damping due to dissipation of energy in the coil itself, and then that due to dissipation in the core. The paper concludes with some general remarks on the effect of phase-swinging on the generator, and flywheel design. A. H.

83. *Phase-angle Measurement.* **A. S. M'Allister.** (Elect. World and Engineer, 38. p. 849, Nov. 23, 1901.)—The author describes a method of measuring the angle of lag in three-phase circuits by one wattmeter.

The wattmeter is inserted in one line, and two readings taken, with the shunt coil connected between that line and each of the others. If W_1 and W_2 are the two readings, $\tan\phi = \sqrt{3} \cdot \frac{W_1 - W_2}{W_1 + W_2}$.

The voltages on the two circuits must be equal, or else one reading must be corrected to such a value as would have been obtained had they been equal. As a ratio only is required, the wattmeter need not be calibrated. If the circuits be equally loaded, the sum of the readings gives the real power, and the difference the wattless power. G. H. B.

84. *Theory of Magnetic Induction.* **J. Buchanan.** (Phil. Mag. 2. pp. 456–462, Nov., 1901.)—This is a continuation of the work referred to in Abstract No. 1535 (1901). Two hysteresis curves are taken from Ewing's papers, viz., for annealed iron and for hardened iron. These curves are subjected to the harmonic analysis, and thus an application of the general theory stated in the previous paper is obtained. The first three harmonic constituents are determined in each case, and numerical values for the constants are given. The work of the paper is mainly analytical. J. W. P.

85. *Hysteresis in Iron, Measured Statically, and in Alternating and Rotating Fields.* **A. Dina.** (Elettricità, Milan, 20. pp. 614–616, Sept. 28; 628–629, Oct. 5; and pp. 663–665, Oct. 19, 1901. Paper read before the R. Istituto Lombardo di Scienze e Lettere.)—The author employed iron wire of poor quality, and measured its hysteresis statically, *i.e.*, by the ordinary method with a ballistic galvanometer, and also in an alternating and in a rotating field.

The measurements in a rotating field formed the subject of a previous paper by the author [see Abstract No. 2050 (1900)], and the measurements in

an alternating field which are described in the present paper, were undertaken on the same sample of iron for comparison with the previous results. The method employed was to take the current and pressure curves in the magnetising coil; the power spent in the coil, which consists of the ohmic loss in the coil, and the hysteresis in the iron can be calculated from these. The frequency adopted was 40 $\sim$, or double that in the case of the rotating field. The hysteresis in a rotating field was found to be lower than that in an alternating field, the difference increasing from 4 per cent. at B = 7,000 to 15 per cent. at B = 18,000. The hysteresis in an alternating field was uniformly higher than that measured statically, the percentage difference being constant at 7·3 per cent. in the limits of measurement, from B = 4,000 to B = 18,000. The permeability to alternating current was less than that measured statically, the percentage difference varying from 13 per cent. at H = 7·5, B = 4,760, to 3·5 per cent. at H = 50, B = 18,000. G. H. B.

86. *Variation of Hysteresis with Induction.* **H. Maurach.** (Ann. d. Physik, 6. 3. pp. 580–589, Nov., 1901.)—The author undertook experiments on a sample of transformer iron, to find the variation of the exponent in Steinmetz's formula $W = \eta B^x$. Measurements were made by the ballistic method.

The exponent x was found to decrease as the induction increased; from H = 0·3 to H = 3 there was a rapid fall from 2·47 to 1·94; from H = 3 to H = 12 the fall was slower to 1·33; and from H = 12 to H = 28, it was still slower, the lowest value being 1·22. G. H. B.

87. *Variations of Magnetisation in Cubical Crystals.* **Wallerant.** (Comptes Rendus, 133. pp. 630–632, Oct. 21, 1901.)—Weiss has shown experimentally that the induction in the interior of a crystal of magnetite placed in a uniform field, varies with the direction of this field. The author of this note establishes the relations existing between this induction and the direction of the field, on the supposition that the induction is uniform in the crystal. J. J. S.

88. *Magnetic Expansion of Iron.* **E. Rhoads.** (Phil. Mag. 2. pp. 463–468, Nov., 1901.)—A narrow strip of sheet tinned iron, 21 cm. long, is taken. To each end of the central 7 cm. a tube is clamped. These tubes are concentric and end near one another, so as to actuate a system of levers and optical lever. Also by constructing one tube of brass and platinum, and the other of brass only, temperature compensation is made. The system is fitted within a coil 24 cm. long, water jacketed on the inside, and the whole is suspended by rubber to avoid vibrations. Smooth hysteresis curves, such as Nagaoka first obtained, are found. The results obtained are—(1) Change in diameter probably does not affect the shape of the curves. (2) Small changes occur in the curve if the specimen be removed and returned to its place, apparently exactly as before; this is not yet explained. (3) Annealing causes higher maxima; shearing causes lower maxima, corresponding to the softening and hardening of the substance. P. E. S.

89. *Longitudinal Thermomagnetic Effect.* **G. Moreau.** (Journ. de Physique, 10. pp. 685–691, Nov., 1901.)—Let a wire or sheet of bismuth be arranged in a magnetic field normally to the lines of force, supposed horizontal, and let a vertical flow of heat be established in the metal. Under the action of the field there is produced parallel to the flow of heat an e.m.f.

independent of the *sense* of the field. This longitudinal thermomagnetic effect is totally different from the transversal thermomagnetic effect analogous to the Hall effect.

After describing briefly the experiments carried out by Lownds on bismuth [see Abstracts Nos. 1680 and 2158 (1901)], the author gives an account of his own researches on the magnetic metals nickel, soft iron, and soft steel. On plotting curves with the thermomagnetic effect n as ordinate, and the strength of field as abscissa, it is noticeable that a point of inversion occurs in each case. The value of n first decreases as the field is made stronger, then reaches a minimum (which differs for each metal), and next rises, at first rapidly, attaining a positive value, and then more slowly. The curves are analogous to those obtained in the case of bismuth, but may be said to be opposite in sign, as for bismuth there is first a rise to a positive maximum, and then a decrease to a negative value.

In considering the interpretation of the results the author refers to the investigations of Houllevigue [Ann. de Phys. et Chim. 7. 1896], according to which the Thomson effect in a magnetic metal varies with the longitudinal magnetisation. Between two successive sections at the temperatures T, and T + dT, the magnetisation introduces a difference of potential

$$dh_1 = \sigma_1 d\mathrm{T},$$

where σ_1 is the change in the specific heat of electricity σ under the action of H.

According to Houllevigue, between two successive sections of a metal unequally magnetised, there is a difference of potential

$$dh_2 = \lambda d\mathrm{H},$$

where λ is a coefficient analogous to σ_1 ; it is a function of H and of T. Like σ_1 it does not change sign with H.

The same coefficients can be defined for the transversal magnetisation. On evaluating the fall of potential under the action of the field in the vertical branch of the sheet or wire with its flow of heat, then—

$$\mathrm{V_B} - \mathrm{V_A} = \int_{t_a}^{t_b} \sigma_1 \, d\mathrm{T} + \int_0^{\mathrm{H}} (\lambda - \lambda_1) d\mathrm{H}.$$

Here t_a and t_b are the temperatures at two neighbouring points a and b in the unequally heated metal, a being at a higher temperature than b, and the portion between these points being placed in a magnetic field : λ refers to one portion of the wire above a, and λ_1 to another part below b when the field varies. But λ is greater than λ_1, for the coefficients σ_1 and λ increase with the temperature.

According to Houllevigue, σ_1 is negative if H is inferior to 250 units. This number refers to longitudinal magnetisation ; it must be raised if the sheet is magnetised transversally. Besides, $\lambda - \lambda_1$ is negative and feeble for small fields ; then $\mathrm{V_B} - \mathrm{V_A}$ is first positive, and changes sign for a value of H which depends on the mean temperature of the plate. The longitudinal thermomagnetic current will flow, first with the flow of heat, and then against it, through the exterior circuit.

The author's general conclusion is that the thermomagnetic longitudinal effect may be regarded as resulting from a modification of the thermoelectric elements.

J. J. S.

ELECTROPHYSIOLOGY.

90. *Skin Currents: Frog's Skin.* **A. D. Waller.** (Roy. Soc., Proc. 68. pp. 480–494, Sept. 27, 1901.)—The normal current is ingoing (from the outer surface inwards) and is greater the more lively the skin. Under a direct excitation (mechanical, or by single induction shocks, by a series of alternating induction shocks or by condenser discharges), the response is an outcoming current, which is greater the greater the excitation, and is greater when the exciting discharge passes inwards, and also presents the phenomena of summation and of fatigue; it is abolished at temperatures above 45° or below 6°, and by mercuric chloride. Under indirect excitation through the nerves of a nerve-skin preparation, the most normal response is an outcoming current; the most enduring is an ingoing current; and in some cases we have the one or the other, followed or interrupted by the opposite current. The interval of time between the excitation of the nerve and the electrical response of the skin is about two seconds. The electrical conductivity of living skin is greatly augmented both by direct excitation and by indirect excitation through nerve. Atropine directly applied to the skin abolishes the effect of indirect excitation. The electrical response of the skin to direct electrical excitation is at or near its external surface. Bibliographical notes as to the history of the question are given in the paper. A. D.

91. *Blood-compounds in Magnetic Field.* **A. Gamgee.** (Roy. Soc., Proc. 68. pp. 503–512, Sept. 27, 1901.)—It is known that blood is strongly diamagnetic, and the blood corpuscles more diamagnetic than the liquid in which they float. The author now finds that oxyhæmoglobin, CO-hæmoglobin and methæmoglobin are strongly diamagnetic, but that hæmatin and acethæmin (hæmin) are strongly magnetic. This led to electrolytic experiments in which it was found that solutions of pure oxy-hæmoglobin under electrolysis promptly precipitate their oxyhæmoglobin in a form still soluble: that solutions of CO-hæmoglobin do the same; that, on continuing the current, secondary reactions occur, from which it is probable that in the blood-colouring matter the iron-containing group on which its physiological properties depend, is, or is contained in, an electronegative radical. According to analogy the iron in such a compound would possess diamagnetic and not magnetic properties. A. D.

REFERENCES.

92. *Magnetic Effect of Electric Convection.* **H. A. Wilson.** (Phil. Mag. 2. pp. 319–320, Sept., 1901.)—This is a further criticism of Crémieu's experiments on this subject. [See Abstracts Nos. 2138 and 2139 (1901).] W. C. H.

93. *Development of the Electron Idea.* **W. Kaufmann.** (Phys. Zeitschr. 3. pp. 9–15, Oct. 1, 1901. Paper read before the 73 Naturforscherversammlung at Hamburg. Translation in the Electrician, vol. 48. pp. 95–97, Nov. 8, 1901.)

94. *Values of the Terrestrial Magnetic Elements at Potsdam for* 1900, *and of the Secular Variations from* 1890 *to* 1900. **M. Eschenhagen.** (Ann. d. Physik, 6. 2. pp. 424–427, Oct., 1901. Communicated by the Königl. Preuss. Meteorolog. Instituts.)—The paper contains a brief summary of observations at the magnetic observatory of the Royal Prussian Meteorological Institute.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

95. *Mathematical Expression of the Periodic Law.* **S. H. Harris.** (Journ. Phys. Chem. 5. pp. 577–586, Nov., 1901.)—Comparing Venable's table of the elements with a table of the atomic weights, the author deduces various numerical relations. In particular, calling the series Li, Be, B, C, N, O, F, bridge elements and Na, Mg, Al, Si, P, S, Cl, typical elements, he states the approximate law that the ratios of the logarithms of the atomic weights of bridge elements and typical elements, which stand next to them in the table, decrease in a certain geometrical progression as we pass from the left, or positive, side of the table toward the central carbon atom, and increase as we pass from the carbon atom toward the right, or negative, end of the table. The relations deduced are used for estimating the atomic weights of missing elements. W. E. T.

96. *Reversion of Flames.* **E. Mameli** and **M. Comella.** (Accad. Lincei, Atti. 10. p. 139, Sept. 15, 1901.)—An arrangement is described for producing a flat disc of flame in which the one side presents gas burning in air and the other side air burning in gas. A. D.

97. *Uranium and its Compounds.* **J. Aloy.** (Annal. Chim. Phys. 24. pp. 412–432, Nov., 1901.)—The author gives an account of his researches on (1) the preparation of uranium; (2) uranous and uranic salts, and (3) the determination of the atomic weight of uranium, the method employed being the measurement of the volume of nitrogen and of the weight of oxide obtained from a given weight of uranium nitrate. The mean value found for the atomic weight of uranium, taking oxygen as 16, is 239·40. The numbers obtained by previous observers are given. T. H. P.

98. *Sulphuric Anhydride and Disulphuric Anhydride.* **G. Oddo.** (Accad. Lincei, Atti, 10. pp. 207–217, Nov. 3, 1901.)—The connection between the liquid and crystalline forms of what is usually known as sulphuric oxide, or as sulphur trioxide, has up to the present time never been clearly established. In the present paper it is shown by cryoscopic determinations of the molecular weight in phosphorus oxychloride solutions, that the solid form, S_3O_6, is a polymer of the liquid modification, SO_3. D. H. J.

99. *Specific Volume as an Indication of Chemical Combination in Alloys.* **E. Maey.** (Zeitschr. Phys. Chem. 38. pp. 292–306, Sept. 17, 1901.)—The existence of definite chemical compounds in alloys or mixtures of two or more metals can, in general, only be deduced from a series of determinations of some quantitative property which is a continuous function of the composition of the alloy. For this purpose the melting-point, heat of combination, electrical properties, &c., have been employed, and the use of the specific volume is now advocated. The examination of published results shows that there is no evidence of the existence of compounds in the case of bismuth-antimony, bismuth-tin, cadmium-tin, lead-tin, lead-silver, silver-copper, gold-copper, gold-silver, gold-tin, iridium-platinum, bismuth-cadmium, silver-bismuth, mercury-lead, mercury-tin, tin-antimony, tin-zinc, lead-cad-

mium, and lead-antimony alloys—a conclusion which is in accord with the results obtained by other methods. On the other hand, the investigation of some other alloys yielded results, which are given in the paper in the form both of tables and curves, indicating the existence of the compounds $SnAg_3$, Au_2Bi_3, Au_2Pb_3, BiPb or Bi_2Pb_3, FeSb, $SnCu_3$, and $CuZn_2$. N. L.

100. *Volume and Density Changes produced in Liquids by Absorption of Gases.* **E. Wenzel.** (Ann. d. Physik, 6. 3. pp. 520–532, Nov., 1901.)—The author gives the results of an examination of the increase of volume of water, caused by its absorption of different proportions of hydrogen, oxygen, carbon dioxide, sulphur dioxide and ammonia. From these numbers the density of each gas as it exists in solution can be calculated. These densities are given in the following table for solutions containing different proportions of the amount of gas present in a saturated solution :—

Percentage.	SO_2	CO_2	O	NH_3	H
10.....	2·5825	1·2904	1·2604	0·7526	0·0782
20.....	2·3985	1·3007	1·2582	0·7606	—
30.....	2·3245	1·3024	—	0·7658	0·0786
40.....	2·2836	—	1·2831	0·7699	—
50.....	2·2548	1·3050	1·2671	0·7739	0·0776
60.....	2·2302	1·3041	—	—	0·0782
70.....	2·2096	1·3050	1·2705	—	—
80.....	—	1·3067	1·2615	—	0·0783
90.....	—	1·3033	—	—	0·0784
95.....	—	1·2990	1·2626	—	—

The densities of the liquefied gases, according to Landolt and Börnstein's Tables, are : SO_2, 1·4336 (at 0°) ; CO_2, 0·9471 (at 0°) ; O, 0·7555 (at—129·5°) ; NH_3, 0·6364 (at 0°) ; H, 0·025 (at 275 atmospheres pressure). It is evident that there exist very large attractive forces between the separate molecules of a gas in solution, the magnitudes of which are from 2,500–3,000 atmospheres ; it is probable that these forces depend on the chemical nature of the gas as well as on its physical properties. The author's results show that the law of proportionality between increase of volume of the liquid and amount of gas absorbed holds perfectly for gases which are only absorbed to a slight extent, whilst for the more soluble gases this is not the case. T. H. P.

101. *Specific Volume of Liquids at Infinite Pressure.* **S. Pagliani.** (Accad. Lincei, Atti, 10. pp. 69–74, 1901.)—From the equation of van der Waals, reduced to its simplest form for the case of a rarefied gas, Tumlirz [see Abstract No. 622 (1901)] deduced the relations—

$$(1)..... \quad -\frac{1}{v}\left(\frac{\partial v}{\partial p}\right)_T = 12{\cdot}225m\,\frac{(v-a)^2}{Tv},$$

and—

$$(2)..... \quad (v_1 - v_n) = 12{\cdot}225m\,\frac{(p_n - p_1)(v_1 - a)}{T}(v_n - a),$$

v being the volume in c.m. of a kilogramme of the gas, m its molecular weight, p the pressure in atmospheres, v_1 and v_n the specific volumes corresponding with the pressures p_1 and p_n, and a the constant of van der Waals' equation. Expression (1) gives the coefficient of compressibility of the liquid, whilst the constant a is obtained from (2). The values calculated from these equations for the compressibilities of a number of liquids do not

show good agreement with the values experimentally obtained by several observers, and the author considers the deviations to be due to the fact that a varies with the temperature. He has calculated the values of a at various temperatures for a number of liquids, and finds that in general they tend to increase as the temperature is raised, except in the case of ethyl ether, where a decrease occurs; with this ether, too, the ratio of the coefficient of compressibility at 100° to that at 0° is more than 3, whilst with the other liquids examined it is always below 2. In the following table, the values of a are given, together with n, the number of atoms in the molecule, and ma, the product of the molecular weight into the constant a :—

	n	a	ma
Mercury	1	0·00006798	0·013595
Water	3	0·00074573	0·013423
Carbon disulphide	3	0·00064052	0·048680
Ethyl alcohol	9	0·0009970	0·045862
Propyl „	12	0·0010199	0·061194
*iso*Butyl „	15	0·0010429	0·077175
Amyl „	18	0·0010517	0·092550
Ethyl ether	15	0·0011025	0·081590
Benzene	12	0·0009593	0·074825
Toluene	15	0·0009865	0·090758
Xylene	18	0·0010061	0·106647
Cymene	24	0·0010240	0·137216

From these numbers it is seen that, in general, the minimum specific volume a, assumed by a liquid under infinitely great pressure, increases with the complexity of the molecule. Further, the values of the product ma, which are proportional to the molecular volumes, and hence also the values of $\sqrt[3]{m.a}$, which are proportional to the diameters of the molecules, stand in relation to the molecular complexity. T. H. P.

102. *Physics of Water.* **G. F. Stradling.** (Frank. Inst., Journ. 152. pp. 257–268, Oct., 1901.)—Röntgen's theory that water contains two kinds of molecules, which he designates "ice molecules" and "molecules of the second kind," has been worked out quantitatively by Sutherland [see Abstract No. 404 (1901)], and promises to explain many points in which water behaves in an exceptional manner. In addition to the well-known maximum density at 4° C., the minimum of compressibility at 63° C., the decrease by increasing pressure of the coefficient of thermal expansion, the lowering by increased pressure, and by dissolved salts, of the temperature of maximum density, the influence of pressure and temperature on the viscosity of water, the decrease of volume in preparing aqueous solutions, and the low specific heat of solutions as compared with water, can also be explained. "Not only in the matter of solutions, but in other more strictly physical relations, it is a misfortune that the *rôle* of the typical liquid was assigned to water."

T. M. L.

103. *Pyrogenic Reactions and Electric Synthesis.* **W. Löb.** (Zeitschr. Elektrochem. 7. pp. 903–921, Oct. 3, 1901.)—This first instalment deals with chloroform and carbon tetrachloride. By an apparatus figured and described, the compounds are vaporised in a flask containing a spiral of iron, nickel, platinum, or platino-iridium wire heated by an electric current, and the

products, liquid and gaseous, are collected. The temperature of the wires is measured by their resistance. At 850°–950° C., chloroform, besides HCl, yields C_2Cl_4, C_2Cl_6, C_6Cl_6 (hexchlorbenzene) and CO, air being present. A mixture of the vapours of chloroform and aniline, carried over by steam, gave the above products and aniline hydrochloride: on saturating the residue with ammonia, triphenyl-guanidine, $C_{19}H_{17}N_3$, was obtained. Carbon tetrachloride yields a large quantity of free chlorine, with CO, from water present, and a little carbonyl chloride; the residue containing C_2Cl_4, C_2Cl_6, and C_6Cl_6. When this is mixed with air much carbonyl chloride is formed. Similar reactions are obtained with perchlorethylene, C_2Cl_4. The author is further developing this process of treating the vapours of different substances along with chloroform or CCl_4 as a valuable and simple method of synthesis. The different possible reactions are discussed at some length. S. R.

104. *Melting-points of Reciprocal Pairs of Salts.* **W. Meyerhoffer.** (Zeitschr. Phys. Chem. 38. pp. 307–325, Sept. 17, 1901.)—The author describes experiments on the melting of mixtures of two salts, for example potassium chloride and sodium bromide, which do not form an isomorphous mixture, or a double salt. From the occurrence of one or several melting points it can be seen which of the two pairs, KCl + NaBr, and KBr + NaCl, is stable. When equivalent quantities of barium sulphate and potassium carbonate are fused together, the transformation into barium carbonate and potassium sulphate is complete when equilibrium is attained, as the author's melting-point measurements show that this pair is stable. It is uncertain whether this mixture melts without separation of barium sulphate, but such separation is, at most, very small. These results are contradictory to those of Rose, who stated that an excess of potassium sulphate hinders the reaction between potassium carbonate and barium sulphate. The question of the synthesis of minerals by double decomposition is also discussed. T. H. P.

105. *Partially Miscible Liquids Near the Critical Point.* **J. Friedländer.** (Zeitschr. Phys. Chem. 38. pp. 385–440, Oct. 1, 1901.)—The saturation-point of mixtures of water and isobutyric acid can be determined within 0·01°–0·02°, provided that the composition of the mixture does not differ by more than 10 per cent. from the critical proportions; the temperature at which the liquid becomes milky on cooling is usually 0·02° below that at which it becomes clear on warming, and the mean of these two temperatures is taken at the saturation-point; the saturation-point is, however, greatly affected by the purity of the preparations, and was found to be 0·9° lower for a specimen of isobutyric acid recovered from the aqueous mixtures, than for the original acid. Solutions which have approximately the critical composition exhibit a bluish opalescence at temperatures up to 10° above the well-defined saturation-point; unlike a colophonium emulsion, however, this opalescence is not affected by time, and the volume, electrical conductivity, and internal friction of the liquid remains constant during a number of hours.

The temperature coefficient of internal friction increases very greatly in the neighbourhood of the critical point, the maximum value observed being as high as 34·3 per cent. per deg. C. for a mixture of isobutyric acid and water of the critical composition (38·60 per cent. acid), and within 0·15° of the critical temperature (25·80° C.); it falls to 7·0 per cent. at 1° above the critical temperature, and to 3·0° at 10° above; similarly mixtures containing 20 per cent. more or less of the acid have a temperature coefficient of only

3·5 per cent. per deg. C. Similar observations were made with mixtures of phenol and water, and with ternary mixtures of benzene, water, and acetic acid.

Precisely similar results were obtained on studying the opalescence phenomena referred to above. Quantitative determinations were made by means of a colorimeter, and it was found that in mixtures of isobutyric acid and water the opalescence reached a maximum of 69 units for a critical mixture 0·04° C. above the critical temperature, and falling to 4·5 units at a temperature 1° above ; the value also fell to 13 units for a solution containing 4·5 per cent. less acid at a temperature just above its saturation-point, and to 10 units for a solution containing 6·8 per cent. more acid. Entirely opposite results were obtained on studying the density, coefficient of expansion, electrical conductivity, and refractive index of the solutions ; these change quite continuously in the neighbourhood of the critical-point, and do not exhibit maxima or any other abnormal features. T. M. L.

106. *Polymolecular Chemical Reaction.* **A. Schükarew.** (Zeitschr. Phys. Chem. 38. pp. 353–368, Sept. 17, 1901.)—The velocities of the following reactions have been investigated for the purpose of determining the number of molecules taking part in each reaction :—$FeCl_3 + KI$; $+ NaI$; $+ CaI_2$; $+ SrI_2$; $Fe_2(SO_4)_3 + NaI$; $+ CaI_2$; $+ ZnI_2$; $CrO_3 + NaI$ in presence of H_2SO_4 ; + ditto in presence of HNO_3 ; $CrO_3 + SrI_2$ in presence of HNO_3 ; $HNO_2 + NaI$; $HNO_2 + CaI_2$. In the case of ferric chloride and the iodides, the action appears to be monomolecular with respect to iron salt (or ion), and bimolecular with respect to the iodide. Ferric sulphate appears to react with a coefficient smaller than unity : this is ascribed to hydrolysis as a possible cause. CrO_3 enters into reaction with one molecule, the acids with the coefficient 2-2·2, while in this case the iodides give varying coefficients. F. G. D.

107. *Minimum Value of Heat of Combination.* **de Forcrand.** (Comptes Rendus, 133. pp. 681–684, Oct. 28, 1901.)—In this paper the author pursues further the analysis begun in an earlier paper [see Abstract No. 1497 (1901)], and produces a table giving calculated minimum values of the total heat of combination for a number of different bodies. These values have been compared with numerous results actually known in thermo-chemistry, and in many cases a striking verification has been obtained. In no case, excepting some exceptions which are readily explained, have values been found lower than those given in the table. The author therefore believes that his figures give, within 6 or 7 per cent., the true minimum values of the total heat of combination. W. C. H.

108. *Specific Heat of Solutions.* **K. Puschl.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 981–991, 1900.)—The specific heats of some solids and liquids may be calculated by assigning a certain atomic heat to each element, and dividing the sum of atomic heats by the sum of atomic weights. Several cases are worked out. Now, since the specific heat of ice is half that of water, and the specific heat of an aqueous solution is always smaller than the value calculated from the specific heats of the constituents, the discrepancy may be explained by assuming that the specific heat of water decreases in the solution. It is shown that for a large number of aqueous (electrolytic) solutions the product—specific heat × sum of atomic weights is less than the calculated atomic heat, taking specific heat of water = 1, by a number which

is a multiple of 9, *i.e.*, the atomic heat of part of the water is reduced from 18 to 9. For example, $KHO + 30H_2O$ has specific heat ·876, atomic heat 558 ($18 + 30 \times 18$), and sum of atomic weights 596 : now $558 - {\cdot}876 \times 596 = 35{\cdot}9$, or nearly 4×9, as if the solution contained the hydrate $KHO + 4H_2O$, in which the specific heat of the water had the value 0·5. Many other examples are given, some substances, *e.g.*, NaHO, requiring a value 4·5 for the specific heat of the modified water. G. E. A.

109. *Heat of Formation of Carbides and Silicides of Iron.* **E. D. Campbell.** (Electro-Chemist, 1. pp. 231–233, Sept., 1901. Abstract of a paper read before the Iron and Steel Institute, May, 1901.)—The heat of formation of carbide of iron is $C + 3Fe = CFe_3 + 8494$ cal. or 47 calories per gm. of carbide ; that of silicide of iron is $Si + 3Fe = SiFe_3 + 26136$ cal., or 133·1 calories per gm. of silicide. The heat of solution of iron and steel is not appreciably affected by annealing or similar processes unless this alters the solubility of the carbide, or of the phosphorus contained in the metal. T. M. L.

110. *Heat Produced in the Reaction between Oxygen and Potassium Pyrogallate.* **Berthelot.** (Comptes Rendus, 133. pp. 664–666, Oct. 28, 1901.)—There is considerable evolution of heat, which falls off (per grm. molecule of oxygen absorbed) as the reaction progresses. The results obtained at a temperature of reaction of 22° C. are :—

Amount of O absorbed as percentage of total amount absorbable.	Heat evolved in calories per 16 grms. of oxygen.
2·8 per cent.	+ 60·2
6·6 „	+ 50·0

F. G. D.

111. *Action of Ammonia on Metals at High Temperatures.* **G. T. Beilby** and **G. G. Henderson.** (Chem. Soc., Journ. 79. and 80. pp. 1245–1256, Nov., 1901.)—Ammonia is rapidly decomposed when passed through an iron tube heated to 800°, but the iron becomes as brittle as hardened steel, so that it can be shattered by a blow with a hammer ; the iron shows a bright silvery fracture, and under the microscope exhibits a spongy fracture. Copper decomposes ammonia less readily than iron, but is even more profoundly altered ; after exposure to ammonia gas for a few hours at 800°, a copper tube becomes so brittle that it cannot bear its own weight without breaking ; the copper swells very greatly, and observation with the microscope shows that the copper has become spongy and disintegrated throughout ; it retains its colour, and, to a certain extent, its metallic lustre, but appears as if it had been in the fluid state, and blown up into a sponge by innumerable minute gas-bubbles. Many other metals are similarly acted upon, their appearance under the microscope indicating that the action of the ammonia has produced a certain degree of fluidity. When wires of different metals were twisted together, and heated in a current of ammonia, they were found in many cases to have flowed together ; thus iron and copper, iron and gold, gold and platinum, gold and silver, became fused together ; in the case of iron and gold the gold sometimes flowed over the surface of the iron, forming a complete plating.

These effects are shown to be due to the formation of nitrides, which are only stable in presence of a large excess of ammonia and within certain

limits of temperature ; in some cases a marked increase in weight occurs, but usually the weight of the metal remains unaltered, although its structure is profoundly altered by the formation and decomposition of the unstable nitrides. The action proceeds with extraordinary rapidity, and a rod of copper or iron ¼ inch in diameter is penetrated to the core in thirty minutes.

The ammonia is scarcely acted on in an ignited porcelain tube when clean and empty, but more readily when it contains fragments of porcelain (Gmelin). T. M. L.

112. *Theory of Solutions.* **W. Nernst.** (Zeitschr. Phys. Chem. 38. pp. 487–500, Oct. 1, 1901.)—In this paper an attempt is made to develope a theory of solutions applicable to concentrated as well as dilute solutions. Briefly, the method is as follows : Consider the solution in equilibrium with a gaseous phase containing both the solvent and the solutes. Suppose for simplicity there are only three solutes, whose concentrations in the solution are c_1, c_2, and c_3, and whose partial pressures in the gaseous phase are Π_1, Π_2, and Π_3. Then, instead of the simple law $\Pi_1 = A_1 c_1$ where A_1 is a pure temperature function, Nernst writes $\Pi_1 = A_1 c_1 e^{a_{11}c_1 + a_{12}c_2 + a_{13}c_3}$ and corresponding expressions for Π_2 and Π_3. The result of a certain isothermal and reversible cycle is the equation $N\frac{dp}{p} + n_1\frac{d\Pi_1}{\Pi_1} + n_2\frac{d\Pi_2}{\Pi_2} + n_3\frac{d\Pi_3}{\Pi_3} = 0$ where p = pressure of solvent, $c_1 = \frac{n_1}{N}$, $c_2 = \frac{n_2}{N}$, $c_3 = \frac{n_3}{N}$. Substituting in this the values of Π_1, Π_2, and Π_3 assumed above, we get finally after integration—

$$\text{Log}\frac{p_0}{p} = c_1 + \frac{a_1}{2}c_1^2 + c_2 + \frac{a_2}{2}c_2^2 + c_3 + \frac{a_3}{2}c_3^2 + a_{12}c_1c_2 + a_{23}c_2c_3 + a_{13}c_1c_3,$$

where p_0 = vapour pressure of pure solvent. This formula then leads at once to an expression for the osmotic pressure P of the solution, when combined with the equation—

$$P = \frac{S}{M_0} RT \log\frac{p_0}{p},$$

where S = density of pure solvent, M_0 = molecular weight of pure solvent in state of vapour.

On this basis the whole theory can be easily built up. The various subjects considered are Lowering of Freezing-point, Law of Mass Action, Solubility, Electromotive Force, and Heat of Dilution. The paper concludes with polemical matter directed against Arrhenius. F. G. D.

113. *Velocity of Action of Bromine on Ethyl Alcohol.* **S. Bugarszky.** (Zeitschr. Phys. Chem. 38. pp. 561–601, Oct. 18, 1901.)—When bromine is allowed to act on a large excess of 80 per cent. ethyl alcohol the action proceeds quantitatively and completely according to the scheme

$$2C_2H_5.OH + 2Br_2 \rightarrow CH_3.CO.OC_2H_5 + 4HBr.$$

Ethyl acetate and hydrogen bromide are the sole products, and no brominated substitution-products are formed. When only a small excess of the alcohol is used the reaction soon ceases, but can be carried through

completely by neutralising the hydrogen bromide at intervals with potassium hydroxide; in this case the bromine is converted quantitatively into potassium bromide. During the early stages the action proceeds as a reaction of the first order, but the velocity curve soon deviates from the typical form for a reaction of this type, showing that some disturbing influence has begun to operate. A trial experiment showed that this was due to the hydrogen bromide produced, and not to the ethyl acetate, which has no effect on the velocity; hydrogen bromide lessens the velocity of the action, and when it is present in excess the action proceeds throughout as a reaction of the first order. This result is explained by the supposition that the hydrogen bromide is capable of combining with the bromine and rendering it inactive, as represented by the equation $Br_2 + HBr_3 \rightleftarrows HBr_3$. If c_1 be the concentration of the *free* bromine, c_2 that of the free HBr, and c_3 that of the combined bromine and hydrogen bromide (HBr_3), then by the law of mass action $c_1c_2 = Kc_3$, and the value assigned to this constant is $K = 0{\cdot}00441$ at 25° C. The velocity of the interaction with the alcohol may be expressed by the equation $dc/dt = -kc_1$, where c is the concentration of the alcohol and c_1 that of the free bromine; if one minute is taken as the unit of time, then $k = 0{\cdot}1052$. These two equations afford an accurate representation of the experimental facts, and when the interaction of the bromine with hydrogen bromide is allowed for, that of the bromine with alcohol is found to proceed quite normally. T. M. L.

114. *Thermodynamics of Concentrated Solutions.* **A. Schükarew.** (Zeitschr. Phys. Chem. 38. pp. 543–560, Oct. 18, 1901.)—Employing Gibbs' method, the author obtains for the distribution of a solute between two immiscible solvents, at const. pressure and temp., the equation $(c - a)c'/(c' - a')c = \text{constant}$, where c and c' denote any two equilibrium-concentrations of the solute in the two phases, and a and a' the corresponding saturation-concentrations, *i.e.*, the respective solubilities. This equation holds for all concentrations. The author tests the equation by means of Jakowkin's results for the distribution of iodine between water and carbon disulphide, and between chloroform and bromoform, and finds a satisfactory agreement. The equation may be also written $(c - c_0)c'/(c' - c_0')c = \text{constant}$ where, as before, c and c' denote any pair of equilibrium-concentrations, while c_0 and c_0' denote a certain particular pair, and are therefore constant parameters so far as the above equation is concerned. This form of the equation is tested for the cases of the distribution of iodine between CS_2 and aqueous solutions of KI, NaI, LiI and HI, and a moderately good agreement is found. Other cases of distribution give a similar result, *e.g.*, the following distribution-equilibria, ether between water and rubber; β-naphthol between water and naphthalene; methylene green between water and silk.

The author then deals with velocity of solution and rate of diffusion, and finally applies Gibbs' equations to the case of the solubility of a salt in a solution containing another salt with a common ion.

For this case he arrives at the equation $(c_1 - c_{10})/(c_{20} - c_2) = \text{constant}$, where c_{20}, c_2 are any two values for the solubility of the salt, the corresponding values for the concentration of the added salt being c_{10} and c_1 respectively. This equation is tested in the following cases: KBr, KNO_3; KBr, K_2CrO_4; KCl, K_2CrO_4; KCl, NH_4Cl; KCl, NaCl; KNO_3, $K_2C_2O_4$, $2H_2O$; KCl, $KHCO_3$; KBr, KNO_3; KCl, KNO_3.

The agreement here is also of a fairly satisfactory nature. F. G. D.

115. *Cryoscopic Experiments with Methylene Iodide.* **F. Garelli and V. Bassani.** (N. Cimento, 2. pp. 196–203, Sept., 1901.)—Methylene iodide is a difficult substance to use as a cryoscopic solvent, as it crystallises with extreme slowness, and concordant readings can only be obtained by taking many precautions. The readings made even with the solvent alone oscillate about two points, differing by about 0·4°, as if the liquid possesses two distinct freezing temperatures. From measurements with ethylene di-bromide, benzene and iodine, the molecular depression of the freezing-point of methylene iodide is found to be roughly 140. Stannic iodide, arsenic tri-iodide, and mercuric iodide have normal molecular weights in this solvent, and sulphur gives a value corresponding with the molecule S_8. T. H. P.

116. *Internal Friction in Alcoholic Solutions of Salts.* **G. Haffner.** (Phys. Zeitschr. 2. pp. 739–742, Sept. 21, 1901.)—Nearly all the properties of solutions progressively rise or fall with increasing concentration. An exception, first noticed by Sprung (Diss. Leipzig, 1876), occurs in the internal friction of aqueous saline solutions, which first diminishes and then increases. For this relation Arrhenius's formula of 1887 has been repeatedly employed, and yields satisfactory results when the concentration is about 1½ normal. The author now examines (1) whether Sprung's minima, especially shown by good conductors of electricity, are also exhibited with mixtures of alcohol and water, (2) whether Arrhenius's formula, viz., $\eta = A^x$, where η is the internal friction, x the concentration, and A a constant, holds good for alcoholic solutions of certain concentrations. After many trials, an apparatus, similar to Wiedemann's, with straight capillaries of circular section, was found best. Tables and curves are given of the results with ammonium chloride and nitrate, showing that dilute alcohol up to 22 per cent. behaves like water, but that with greater strengths, up to absolute, the phenomena are different. The conclusions are (1) that addition of a salt always raises the internal friction ; (2) that this rise decreases with increasing concentration, giving curves concave to the x-axis ; whence it follows that Arrhenius's formula, $\eta = A^x$, always positive, is not applicable, as it gives a curve which is convex to the x-axis ; (3) consequently also no Sprung's minima, but, on the other hand, maxima are developed ; (4) the influence of these salts declines with rising temperature, as it does when non-electrolytes are added to water (Arrhenius, 1887) ; the curves (isotherms) diverge also in this case. S. R.

117. *Chemical Pseudo-Equilibria and Explosive Systems.* **L. Marchis.** (Journ. de Physique, 10. pp. 525–542, Sept., 1901.)—This is a continuation of a previous paper on the same subject [see Abstract No. 2061 (1900)]. The paper, according to a footnote of the author, does not contain any new facts or theories, but is simply an exposition in "ordinary language" of Duhem's theory, as set forth in the latter's Treatise on Chemical Mechanics, pp. 246–289. The subject treated of in this communication is the application of the theory of pseudo-equilibria to the conditions which determine the stability or instability of chemical systems ; in particular, the conditions which determine the *explosion* of a gaseous system. It contains, therefore, an outline of Duhem's theory of explosions, and will be of value to those interested in explosives, as giving a concise and clear account of modern theoretical advances in this subject. F. G. D.

118. *Temperature Limits for the Separation of Graphite from Martensite in Pure Cast Iron.* **H. P. Tiemann.** (Metallographist, 4. pp. 313–332,

Oct., 1901.)—Attention is called to the enormous influence of silicon in determining the separation of graphite from cast iron. It is somewhat difficult to secure the absence of this impurity from iron, and a large number of the recorded experiments are of little value, owing to this important factor having been overlooked. Experiments are now described which were made with a sample of iron containing no silicon, 0·031 per cent. P, 0·002 per cent. S, 0·040 per cent. Mn, and 0·030 per cent. combined carbon; this was carburised with sugar-charcoal in crucibles, free from silica, until it contained 4·271 per cent. combined carbon and 0·255 per cent. graphite. It was found that the proportion of graphite was quite unchanged by heating up to temperatures as high as 1,116° C., and then quenching in iced brine at — 5° C.; when heated to 1,300°, and allowed to cool to 1,040° before quenching, the proportion of graphite was raised to 0·677 per cent.

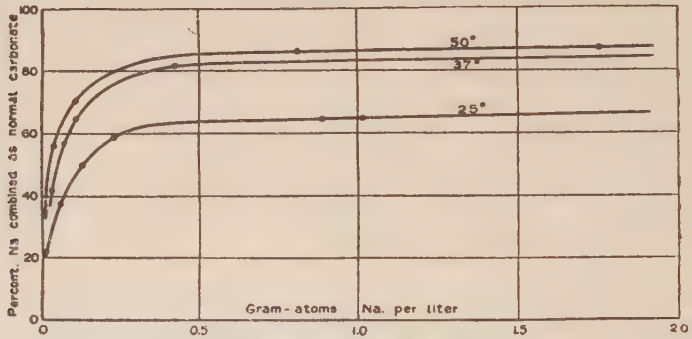
According to Roozeboom's diagram, cementite (combined carbon) should be entirely converted into graphite at any temperature above 1,000°. The results here described go to show that this change does not readily take place in a pure cast iron unless the temperature is raised far above the "transition-point." On the other hand, an iron containing 0·75 per cent. Si, 3·438 per cent. combined carbon, and 0·938 per cent. graphite, was found to contain 2·795 per cent. graphite when heated to 1,125° and quenched at — 5°, and the proportion of graphite was increased to 1·690 per cent. when the iron was heated only to 975°, a temperature 25° below the transition-point; this shows that the silicon not only facilitates the formation of graphite above the transition-point, but also lowers the transition-point, so that the formation of graphite may take place below 1,000° C. T. M. L.

119. *Periodic Electric Phenomena in the Solution of Chromium in Acids.* **E. Brauer.** (Zeitschr. Phys. Chem. 38. pp. 441–486, Oct. 1, 1901.)—Further particulars are given of Ostwald's researches [see Abstract No. 163 (1901)] which the author is continuing. Two types of recording instruments are described. The one registers photographically both the gas pressure of the hydrogen, evolved during the solution of chromium in the hydrochloric acid, and the current intensity; in the other a syphon traces the current curve only. The two curves are perfectly parallel, and analogous to one another; the pressure curve fluctuations lag a little behind the current fluctuations, however, and are not quite so sensitive. A very pure chromium displayed no periodic phenomena, which appeared when arsenic or sulphur were added to the acid. These two elements were found in most of the chromium specimens experimented with, but the so-called "oscillating" chromium (exhibiting periodic phenomena) is more pure in this respect than the non-oscillating metal. General conclusions cannot yet be drawn. H. B.

120. *Inversion-points of Dilutions.* **A. Colson.** (Comptes Rendus, 133. pp. 585–587, Oct. 14, 1901.)—Berthelot has shown that in the case of some salts there is a temperature at which the heat of solution changes sign. The author finds that the heat of *solution* of 25 grm. NaCl in a litre of water is zero at 70°, and that of 75 grm. in a litre is zero at 75°. The heats of solution become identical at 52°, *i.e.*, the heat absorption is the same when 75 grm. NaCl is dissolved in 1 litre or in 3 litres of water; from this it follows that the heat of *dilution* is zero at 52°, and changes sign at this temperature, being positive at higher and negative at lower temperatures. The inversion-point of sodium chloride is raised by the addition of hydrochloric acid or caustic soda; in presence of 1 molecule of HCl per litre the inversion-point

is 83°, and in presence of 2 molecules per litre 100°; in presence of 1 molecule of NaOH per litre the inversion-point is 80°, and in presence of 2 molecules per litre 100·8°; the acid and alkali thus produce almost identical effects. T. M. L.

121. *Equilibrium between Carbonates and Bicarbonates in Aqueous Solution.* **F. K. Cameron** and **L. J. Briggs.** (Journ. Phys. Chem. 5. pp. 537–555, Nov., 1901. Contribution from the Bureau of Soils, U.S. Dept. of Agriculture.)—The discovery, in the author's laboratory, that both carbonates and bicarbonates can be readily estimated when present together in the same solution, by adding phenol phthalein, running in standard potassium hydrogen sulphate until the pink colour due to the indicator disappears, then adding methyl orange, and continuing the titration until neutrality has been obtained, has enabled the authors to investigate the distribution of the base between carbonic and bicarbonic acids, in the case of sodium, potassium, and



magnesium carbonates in solutions which are in equilibrium in contact with air.

For the experiments, the solutions to be examined were arranged in flasks placed in a water-bath and connected together by a system of stoppers and tubing. Air was aspirated through the flasks until equilibrium was established; the contents of the flasks were then titrated. The accompanying diagram gives the results for sodium carbonate the other substances give similar results. D. H. J.

122. *Alkali Salts of Hydroperoxide in Aqueous Solution.* **H. T. Calvert.** (Zeitschr. Phys. Chem. 38. pp. 513–542, Oct. 18, 1901.)—The fact that hydroperoxide, a name suggested by v. Baeyer for hydrogen peroxide, exhibits acid functions, has been shown by several physico-chemical methods. With the alkali hydroxides, hydroperoxide forms salts which are appreciably hydrolysed in solution; the amount of hydrolysis can be diminished by the presence of excess of hydroperoxide, owing to the formation of acid salts of the type MO_2. The proportion of hydroperoxide which can be removed from solution in an alkali by shaking up with amyl alcohol is less than that removed from aqueous solutions; the results of experiments show that one equivalent of alkali combines with 1·5 molecule of hydroperoxide. The acid alkali salts MO_2 of hydroperoxide form monovalent oxygen ions of the composition O'_2, which ions in some cases undergo hydration. The velocity of this ion has a mean value of 48·5. The conductivity of alkali salt solutions is lowered by the addition of hydroperoxide, but not to a greater extent than by non-electrolytes,

so that no formation of a complex ion containing an alkali metal takes place. The solubility of potassium chlorate in hydroperoxide solution is considerably greater than in water. Freezing-point measurements of solutions of salts, the extent of hydrolysis of which has been depressed by addition of excess of alkali, indicate the existence of divalent ions of the composition O_2'', but no confirmation has as yet been obtained of this. T. H. P.

123. *Solubility of Gypsum in Aqueous Solutions of Sodium Chloride at Different Temperatures.* **F. K. Cameron.** (Journ. Phys. Chem. 5. pp. 556–576, Nov., 1901. Contribution from the Bureau of Soils, U.S. Dept. of Agriculture.)—Below 37°·5 C. the experimental results show a maximum solubility point. Above this temperature the existence of such a point is doubtful. A condensation of the water as solvent takes place when gypsum and sodium chloride are brought into solution. D. H. J.

124. *Physical Properties of Nitric Acid Solutions.* **V. H. Veley** and **J. J. Manley.** (Roy. Soc., Proc. 69. pp. 86–119, Nov. 19, 1901.)—The densities of mixtures of pure nitric acid and water were determined at 4°, at 14·2° and at 24·2°, and curves were plotted showing the contraction in the formation of 1 grm. of the solution. These curves could be represented by a series of straight lines, the intersections being replaced on the experimental curves by continuous lines; the chief intersections were at about 20, 33, 42, 54 (max. contraction), 63, 70, and 78 %, corresponding to the hydrates $HNO_3 . 14H_2O$ (20·31 %), $HNO_3 . 7H_2O$ (33·33 %), $HNO_3 . 4H_2O$ (41·18 %), $HNO_3 . 3H_2O$ (53·93 %), $HNO_3 . 2H_2O$ (63·63 %), $2HNO_3 . 3H_2O$ (70 %), and $HNO_3 . H_2O$ (77·77 %).

A refractive index curve, plotted in a similar way, gave intersections at 20, 33, 40, and 70 % maximum refraction, corresponding with the hydrates containing 14, 7, 4, and 1·5 molecules of water respectively. T. M. L.

125. *Proof of Formula for Lowering of Freezing-point of Solutions.* **F. Lengfeld.** (Journ. Phys. Chem. 5. pp. 499–501, Oct., 1901.)—A proof of van't Hoff's formula, $dT = 0{\cdot}02T^2/L$, for the lowering of the freezing-point of a solution is derived from the consideration of a solution, in a cylinder with a semi-permeable end and a movable piston, being submitted to the following cycle of changes. A quantity of the solvent is frozen out at the freezing-point of the solution and separated from the solution. The temperature of the whole is raised to the melting-point of the solvent and the solvent allowed to melt. The liquid solvent is brought into contact with the solution at the semi-permeable membrane, the pressure being equal to the osmotic pressure, and by raising the piston under this constant pressure the solvent passes through the diaphragm. Finally the whole is brought back to the original temperature. W. E. T.

126. *Velocity of Decomposition of Ammonium Nitrite.* **K. Arndt.** (Zeitschr. Phys. Chem. 39. pp. 64–90, Nov. 12, 1901.)—The author describes a number of experiments on the decomposition of ammonium nitrite under various conditions, and from his results draws the following conclusions. The reaction consists in a decomposition, under the influence of free nitrous acid, of the non-dissociated portion of the ammonium nitrite into nitrogen and water. A rise of temperature of 10° (60°–70°) causes a threefold increase in the velocity of decomposition. The addition of ammonium sulphate also increases the

velocity of the reaction owing to a depression of the dissociation of the ammonium nitrite. Sodium nitrite has a similar action, since it both lowers the amount of dissociated ammonium nitrite and increases the concentration of the free nitrous acid. All salts containing neither NH_4 or NO_2 diminish the velocity of the reaction, potassium salts having a greater effect than those of sodium, whilst magnesium salts have a still slighter action; sulphates cause a greater diminution than nitrates or chlorides. This lowering of the velocity of decomposition depends on the diminution of concentration of the ammonium nitrite and also of that of the free nitrous acid due to the difference of the degree of hydrolytic dissociation. Very small proportions of ammonia bring about very considerable diminution in the velocity of the reaction, which is greatly accelerated by small quantities of acid. From the magnitudes of these influences, it follows that in a 0·6 normal aqueous solution, ammonium nitrite is resolved into free acid and base to the extent of about 0·5 per cent. at 75° and 0·25 per cent. at 70°. T. H. P.

127. *Constitution of Inorganic Compounds.* **A. Werner** and **C. Herty.** (Zeitschr. Phys. Chem. 38. pp. 331–352, Sept. 17, 1901.)—The author first discusses the objections raised by Petersen to his method of determining the type of a salt by means of the molecular conductivity at a certain dilution, and then goes on to show that the order of magnitude of the conductivity gives a certain indication as to whether a salt splits up into two or three or more ions. The authors' experiments show that by the replacement of two molecules of ammonia in the complex cobalt compounds by ethylenediamine, the molecular conductivity is lowered. Measurements of the conductivity of and of the depression of the freezing-point by 1:6- and 1:2-dichlorodiethylene-diaminecobalt chlorides and nitrates, which in aqueous solution undergo gradual hydrolysis and are changed from two-ion into three-ion salts, show that at 0° and at 25° these salts in water form two ions. Results are given of the measurement of conductivity of several other cobalt-ammonia and platinum-ammonia compounds. T. H. P.

128. *Dissociation Relations of Ternary Electrolytes.* **K. Drucker.** (Zeitschr. Phys. Chem. 38. pp. 602–608, Oct. 18, 1901.)—Assuming the validity of the law of mass action, the author obtains equations which can be applied to experimental results for the purpose of ascertaining the complex ions existing in solutions and for determining the concentration of the ions of a mono- and di-valent salt. If a salt of the type AB_2 forms no complex ions AB, A can be directly calculated from the difference of the values of the total concentration obtained from osmotic measurements and those arrived at analytically. From his experimental numbers, the author concludes that sulphuric acid is dissociated directly into SO_4 and H ions, and forms no ions of the form HSO_4. T. H. P.

129. *Dissociative Power of Different Solvents.* **H. C. Jones.** (Chem. News 84. pp. 95–96, Aug. 23; 106–108, Aug. 30; 135–136, Sept. 13; p. 146, Sept. 20 and pp. 159–160, Sept. 27, 1901. From the Amer. Chem. Journ. 25. No. 3.)—The author gives a summary of all the work published on the dissociative power of solvents, the latter being divided under the following heads. *Inorganic solvents:* Including water, ammonia, nitric acid, sulphur dioxide, sulphur dichloride, sulphuryl chloride, thionyl chloride, phosphorus oxychloride, arsenic and antimony trichlorides, halides of boron, phosphorus, silicon and tin, and sulphur trioxide and bromine. *Organic solvents:* Methyl

ethyl, propyl, isopropyl, allyl, isobutyl and isoamyl alcohols, ether, ketones, formic and acetic acids, the nitriles, pyridine, ethyl sulphide, glycerin, benzene, xylene, hexane, benzene chloride, ethyl iodide and bromide, amyl acetate, acetophenone, ethyl acetate and acetoacetate, benzaldehyde and nitrobenzene. *Mixed solvents:* Hydrogen dioxide and water; alcohols and water.

An examination of the work reviewed shows that different solvents have very different ionising powers; with the possible exception of hydrogen dioxide, water is the strongest ioniser, formic acid coming next. Methyl alcohol dissociates to a much greater degree than ethyl alcohol, and in general the lower members of a homologous series of solvents have the greater dissociative power. A high dissociating power is, as a rule, accompanied by a high dielectric constant, but the two constants are not proportional to one another. Dutoit and Aston's suggestion that there is some connection between the amount of association of the molecules of a solvent and its power to ionise electrolytes is doubtless true; thus, for example, the molecule of liquid water at ordinary temperatures is $(H_2O)_4$, while the alcohols and other strongly dissociating solvents show considerable association of their molecules. It is probable, however, that the dissociative power of a solvent depends on all its physical and chemical properties. The most important conclusion to be drawn from the work here reviewed is that ions are almost always present when chemical reaction takes place, and by preventing the formation of ions chemical action may be stopped. Thus a chloroform solution of dry hydrogen chloride will not decompose carbonates, while dry ammonia and hydrogen chloride do not react, and dry liquid hydrogen chloride does not act on litmus. All the evidence goes to show that only ions are capable of taking part in chemical actions. T. H. P.

130. *Contact E.M.F.'s and the Ionic Theory.* **E. Rothé.** (Journ. de Physique, 10. pp. 546–555, Sept., 1901.)—This is a full account of experiments, a note on which has already appeared in the Comptes Rendus [see Abstract No. 1970 (1901)]. The line of argument is as follows:—Consider the e.m.f. of a concentration cell, the electrodes being mercury, and the solutions being saturated with respect to mercurous sulphate or chloride, but containing different amounts of sulphuric or hydrochloric acid respectively. Denoting by Hg | L the p.d. at a metal-liquid junction, and neglecting the small p.d. at the liquid-liquid junction we have according to the ionic theory $\mathrm{Hg} \mid \mathrm{L}_1 - \mathrm{Hg} \mid \mathrm{L}_2 = \frac{RT}{n\varepsilon} \log \frac{p_2}{p_1}$ using the ordinary notation. Putting $\frac{p_2}{p_1} = \frac{c_2}{c_1}$, when c_2 and c_1 are the concentrations of the mercurous ions, and taking into account the small solubility of the mercurous salts even in their saturated solutions, it follows from the law of mass action that $\frac{c_2}{c_1} = \frac{c'_1}{c'_2}$ where c'_1 and c'_2 are the concentrations of the SO_4 or Cl ions. And, very approximately, $\frac{c'_1}{c'_2} = \frac{a_1 C_1}{a_2 C_2}$, where C_1 and C_2 are the acid concentrations, and a_1 a_2 he corresponding degrees of ionisation. Thus we get—

$$\mathrm{Hg} \mid \mathrm{L}_1 - \mathrm{Hg} \mid \mathrm{L}_2 = \frac{RT}{n\varepsilon} \log \frac{C_1 a_1}{C_2 a_2}$$

Accordingly, any one of a series of values of the single p.d., Hg | L, can be calculated from any other, since the value of the right-hand member of the

above equation can be calculated from known data on the conductivity of solutions of sulphuric and hydrochloric acids. The author obtains this series of values of the single p.d. Hg | L by using the above solutions in turn in a Lippmann electrometer, bringing the surface tension to its maximum value by a compensating p.d., and assuming then in the well-known way that the p.d. at the capillary electrode is zero, so that the value of the compensating p.d. gives the value of Hg | L at the large mercury electrode in each particular case. Taking now Hg | L for the sulphuric acid solution of density 1·0337 equal to 0·892 volt, and Hg | L for the hydrochloric acid solution of density 1·017 equal to 0·568 volt, the following results are obtained :—

1. Sulphuric Acid Solutions.

Density.	P.D. (volts.)	
	Observed.	Calculated.
1·0033	0·87	0·865
1·0062	0·875	0·873
1·0167	0·883	0·884
1·03107	0·890	0·891
1·0337	0·892	(0·892)
1·0340	0·894	0·8945
1·0682	0·910	0 901
1·1048	0·925	0·903

2. Hydrochloric Acid Solutions.

Density.	P.D. (volts.)	
	Observed.	Calculated.
1·0010	0·554	0·542
1·0081	0·560	0·5605
1·017	0·568	(0·568)
1·0242	0·576	0·522
1·0490	0·600	0·578

The agreement is found to be very good, except in the stronger solutions. F. G. D.

131. *Heats of Dissociation and Combustion of Acetylene, Ethylene, and Methane.* **W. G. Mixter.** (Amer. Journ. Sci. 12. pp. 347–357, Nov., 1901.)—The method used by the author for the determination of the heat of dissociation of acetylene is the direct measurement of the heat evolved when the gas is exploded in a calorimetric bomb ; in the cases of ethylene and methane, sufficient acetylene is added to yield a mixture which explodes, the heat developed being determined as before. The following table contains the author's results, the numbers representing calories per grm.-molecule of each gas ; 1 and 12 are taken as the atomic weights of hydrogen and carbon respectively.

	Heat of Formation.	Heat of Combustion.
Acetylene	— 53,300	313,800
Ethylene	— 10,600	345,800
Methane	+ 18,420	—

The above values were obtained at constant pressure. The determinations of other authors are referred to. T. H. P.

132. *Tri-iodides.* **Y. Osaka.** (Zeitschr. Phys. Chem. 38. pp. 743–749, Nov. 1, 1901.)—The author gives results of measurements of the freezing-points of solutions of potassium iodide and hydrogen iodide of different concentrations, before and after the addition of iodine, which causes an elevation of the freezing-point. The differences are, however, independent of the concentration of the iodide, but are proportional to the concentration of the added iodine. In the case of the hydriodic acid, the molecular elevation of the freezing-point is greater than with potassium iodide, and the thermal dissociation constant for hydrogen tri-iodide is perhaps somewhat greater than that of potassium tri-iodide. These results are discussed in relation to those of other investigators, from which they differ. T. H. P.

133. *Polarisation of Aluminium.* **A. Naccari.** (Accad. Sci. Torino, Atti, 36. 12a. pp. 468–481, 1901.)—The author measures separately the polarisation shown by aluminium when used as anode and kathode respectively. The aluminium plate which is to form the electrode is placed in a vessel containing dilute sulphuric acid. The vessel is joined by means of three wide glass siphons with another containing the same liquid and an aluminium electrode. The first vessel is also joined by means of a siphon with another which contains the same liquid and a plate of aluminium. The latter is at a certain moment connected with an electrometer for measuring the potential of the liquid in which the aluminium electrode is immersed, while the electrode itself is connected to earth. The experiments show that the polarisation gradually increases, reaching a maximum of 10 volts in about eight minutes, and then decreasing to about half that amount in about half an hour, after which it remains steadily at that amount. This, however, only applies to fresh plates, for on repeating the experiment with the same plate the next day, the final value of the polarisation is reached almost at once. The author inclines to the opinion that the resistance created by a thin coating of aluminium oxide is the determining factor in the phenomena described. This view is supported by the fact that the polarisation diminishes on increasing the concentration of the sulphuric acid, which would facilitate the solution of the oxide or hydrate. E. E. F.

134. *Standard Cells.* **H. Rupp.** (Elektrotechn. Zeitschr. 22. pp. 544–546; 564–565; and pp. 585–588, 1901.)—The e.m.f. of Clark cells was found by Cooper to depend, not merely on the temperature, but also on the rate of change of temperature—that is to say, if the cell be kept at a constant temperature for a time sufficient to enable the whole cell to reach this temperature, the e.m.f. will still depend on the previous temperature. This is probably due to very slow diffusion and concentration phenomena. The author made experiments to determine to what extent the e.m.f. depended on the previous history of the cell. The temperature was varied, and the e.m.f. both measured and reckoned from Jaeger and Kahle's formula. The cell before experiment had been kept for 75 hours at a temperature of 18°; it was then raised to 21°, and measurements commenced after twenty-four hours. The temperature was gradually increased to 23° during two days, and throughout this time the measured e.m.f. was higher than the calculated by amounts increasing from from 0·00035 to 0·00054 volt. These differences the author attributes to the cell having been kept at the lower temperature of 18°. The cell was then kept at 25°–26° for three days, and again lowered to 23°, when the observed and calculated e.m.f. were practically equal, showing the after-effect of the

higher temperature. Lowering the temperature to 14°, made the observed value smaller than the calculated by 0·00028 volt, even after nine days.

In the Cadmium cell these variations are absent, as the cell has only a negligible temperature coefficient. A comparison was made between two cells, one prepared at the Physikalische Technische Reichsanstalt, the other by the Weston Instrument Company. At 10° C. their e.m.f.'s were 1·01923 and 1·01905 respectively, and at 30° 1·01855 and 1·01915.

Further experiments were made on the behaviour of cells when giving current. The resistance of Clark cells was found to vary considerably with the temperature, with the time during which current was taken, and, to a small degree, with the current. The following figures were obtained from a Clark cell, the current being expressed in micro-amperes, and the measurements being made after four minutes' duration of current:—

Temperature.	Current.	Resistance.
13·10°	2·43	234·7
	14·33	217·5
	141·02	177·8
17·55	2·42	198·3
	14·29	195·7
	141·13	142·3
21·00	2·41	206·8
	14·26	126·1
29·21	2·39	125·3
	14·16	95·2
	140·50	80·4

The effect of duration of current was to diminish the resistance. With 14·3 micro-amperes the resistance was, after 75 secs., 160·8; after three minutes, 149·6; after eleven minutes, 145·4. The Cadmium cells showed a similar behaviour; that prepared by the Reichsanstalt had a high internal resistance of about 2,000 ohms, which varied but little with the current, but which diminished considerably with increase of temperature. The Weston cell showed a small decrease with increase of temperature, but a considerable rise with increase of current; its internal resistance was only about 150 ohms.

The author next determined the variation of potential difference with the current. In the Clark cell the potential difference diminished steadily when small currents were taken; with larger currents it diminished at first and then increased. It was from 1 to 2 per cent. less than the e.m.f. when the cell was closed on 10,000 ohms, the exact value depending on the temperature. The variations with temperature and time are so great as to render the cell useless for measurement except in zero methods. The Cadmium cell is better in this respect, as the variation of the potential difference with time is very small. The author found that it could be expressed by the formula $V = a - bC$, where c is the current, and a and b constants for any one temperature, or, introducing the outside resistance R, by the formula—

$$V = \frac{R(\alpha + \beta t)}{R + \alpha_0 + \beta_0 t + \gamma_0 t^2}$$

This formula, with values for the constants reckoned from one Cadmium cell, was found applicable to the two other cells under measurement to within 0·1 per cent.

Finally, the author observed the time of recovery of e.m.f. after the cell had given current. The Clark cell, after giving 3·7 micro-amperes

for 45 seconds, had an e.m.f. lower by 0·0004 volt, which rose to the normal only after 6 minutes rest. After giving the same current for six minutes the drop was 0·0006 volt, and after 20 minutes' rest was still 0·0002 volt. The Cadmium cell was far better in this respect; after giving 100 micro-amperes for 5 minutes, it recovered its normal e.m.f. in $2\frac{1}{2}$ minutes. After giving this current for nine days, however, the e.m.f. was permanently diminished by 0·0007 volt. G. H. B.

135. *Magnesium in Electrolytic Rectifiers.* **A. Campetti.** (Accad. Sci. Torino, Atti, 36. 7a. pp. 251–256, 1901.)—When a current is passed through a voltameter containing caustic potash or soda, from an anode of magnesium to a kathode of platinum, there is a marked diminution in the strength of the current, which is not due entirely to the opposing e.m.f. of polarisation, but mainly, in the author's opinion, to the formation of a thin badly conducting layer of oxide on the surface of the magnesium. The phenomena are similar to those observed in the case of aluminium, and the cell, when inserted into an alternating-current circuit, acts as an electrolytic valve. With voltages varying from 18 to 60, and with a frequency of 15, calorimetric measurements show that under the most favourable conditions the loss in the cell does not exceed from 10 to 15 per cent. of the energy developed. D. H. J.

136. *Polarisation and Internal Resistance of Electrolytic Cells.* **M. D. Atkins.** (Phys. Rev. 13. pp. 102–124, Aug., and pp. 182–192, Sept., 1901.)—Electrodes of copper in $CuSO_4$, and zinc (amalgamated, either plates or liquid amalgam) in $ZnSO_4$, when freshly placed in their respective solutions, give, with varying currents, curves completely satisfied by a formula of the Bartoli-Wiedeburg form (Wiedeburg, Habilitationschrift Leipzig, 1893; Wied. Ann. 51, 302, 1894; Guthe and Atkins, Proc. A.A.A.S., 1899, p. 109; Guthe, Phys. Rev. 7, p. 38; Wiedeburg, Zeit. Phys. Chem. xiv., 1, 1894), and its derived equations. With such electrodes the internal resistance is therefore constant. Electrodes of silver in $AgNO_3$ and zinc in $ZnSO_4$ in the main give curves satisfied by such a formula; but electrodes of platinum (polished) in H_2SO_4 do not. The maximum value for the polarisation of Pt in H_2SO_4 is, however, in agreement with that found by other methods. Electrodes of all these metals in their respective solutions show, upon standing, a marked increase in apparent resistance; all results obtained concur in their testimony that this is not an increase in the real resistance of the coil. Neither the inverse proportionality of the constant K [K being a constant, defined by the equation $p = P(1 - \varepsilon^{-Kt})$ where p and P are the momentary and maximum polarisations respectively, while t is the time; also $K = \beta I/S$ where β is a constant depending on the electrodes, I is the current, and S is the area of the electrodes] to the area of the electrodes nor its direct proportionality to the time of flow of current is conclusively established. While the theory of Wiedeburg is therefore not sustained as to its constants, an equation of the same general form would seem to be suggested. The method of the research is based on the Bartoli-Wiedeburg formula, where the polarisation-capacity is $c' = \varepsilon^{at}/Pa$ (where a is a constant depending on the size of the electrode) and the initial capacity is $c = t/PK$; whence the constant current method employed. It is found capable of giving the internal resistance within 1 per cent., the maximum value of P, and the polarisation capacity even when this is very large. A. D.

137. *Constitution of Complex Salts according to Electrolytic Behaviour.* **E. Rieger.** (Zeitschr. Elektrochem. 7. pp. 863–868, Aug. 29, and pp. 871–876, Sept. 5, 1901. Also Zeitschr. Anorg. Chem. 25. p. 180, 1900.)—The determination of migration constants, as was shown by Hittorf, throws light on the chemical constitution of complex salts. The author has examined the behaviour on electrolysis of a number of salts, and finds that in potassium copper sulphate, potassium silver iodide, potassium mercury iodide, potassium mercury cyanide, potassium zinc cyanide, potassium cadmium cyanide, potassium ferrous oxalate, and potassium ferric oxalate, the nobler metal travels to the anode, thus indicating the existence of an anionic complex. This conclusion is confirmed by the diminished conductivity of the salt solutions, as compared with the conductivity calculated from that of the components of the complex salt. N. L.

138. *Electrolytic Transport Values and E.M.F. of Reversible Elements.* **R. Gans.** (Ann. d. Physik, 6. 2. pp. 315–330, Oct., 1901.)—The theoretical part of this paper consists of the deduction from thermodynamic principles of various equations showing how the dependence of electrolytic transport values on physical parameters may be ascertained from that of e.m.f. on those parameters. In particular, the author considers the influences of pressure and temperature, pointing out that all relations deduced under the assumption of constant transport values require extension, and determining

$$E - T\frac{dE}{dT} - ET\frac{d\log k}{dT} = Q$$

as the extended form of Helmholtz's equation, in which $k = de/ds$, e is the quantity of electricity sent through, and s is the amount of salt measured in gram-equivalents. Experiments for zinc sulphate lead to the equation $E = 0{\cdot}01644\ (1 + 0{\cdot}000134p)$ for the e.m.f. in volts, p being the increase of pressure in atmospheres; from this is deduced for the transport value of the kation, the equation $1 - n = 0{\cdot}699(1 + 0{\cdot}00012p)$. W. E. T.

139. *A Voltametric Balance.* **W. Pfanhauser, Jr.** (Zeitschr. Elektrochem. 7. pp. 923–924, Oct. 10, 1901.)—This apparatus, which forms the subject of a German patent, consists of a copper voltameter containing a solution of sp. gr. 1·2, and the kathode of which is suspended from one arm of a balance-beam. The other arm of the balance-beam is provided with a scale-pan in the usual way, and weights are added until the kathode is exactly counterbalanced in its normal position, *i.e.*, whilst partly immersed in the electrolyte. When this is so, the kathode-arm of the balance-beam rests on a contact-piece, or stop, insulated from the rest of the frame of the balance, and thus completes the circuit of an electric bell. The scale-pan arm of the balance-beam carries an adjustable contact-piece, which, when the kathode is counterbalanced as above mentioned, is just out of contact with the mercury in a cup, this contact-piece and the mercury being arranged in the main circuit, *i.e.*, in series with the kathode and a plating bath in which a definite amount of, *e.g.* silver, is to be deposited. Weights are then placed in the scale-pan equal to the weight of copper, equivalent to the amount of silver to be deposited, less the loss of weight due to the copper being immersed in the electrolyte in the voltameter. This causes the balance-beam to tilt so as to break the bell-circuit and close the main-circuit. When the predetermined amount of metal has been deposited, the balance-beam tilts

back again, breaks the main-circuit, and closes the bell-circuit, thus giving notice to the attendant. The following table is also given :—

When g grammes of silver to be deposited.	Weight in grammes to be placed in the scale-pan after counter-balancing.
1	0·262
2	0·524
3	0·786
4	1·048
5	1·309
10	2·619
20	5·228
30	7·856
40	10·477
50	13·093
100	26·186

C. K. F.

140. *Electrolytic Production of Alkali and Chlorine.* **A. Cohn** and **E. Geisenberger.** (Elektrochem. Zeitschr. 8. pp. 128–130, Sept., 1901.)—The authors claim to have overcome the two chief defects of the methods now in use, viz., the want of durability of the diaphragms, and the waste of carbon, due to formation of hypochlorite at the anode. The principle of their own method is the use of a temperature so low, that the sodium hydrate separates at the kathode in the solid state.

Two forms of apparatus are described for carrying out their process. The first consists of a cylinder mounted on hollow trunnions and rotating in a vat containing the freezing solution. The cylinder is three-parts filled with the electrolyte, and in its lower part carbon anodes are placed, these being carried on fixed supports. The current passes between these anodes and the wall of the cylinder which acts as kathode. The sodium hydrate separates in the solid state on the wall, and is carried by the rotation of the cylinder up to a fixed scraper, which detaches the hydrate, and causes it to fall into a fixed collecting vessel, from which it is continually removed. The chlorine gas liberated at the anodes is collected by a fixed hood, and passes away from the vessel by the hollow trunnions. A second form of electrolyser consists of a series of inverted funnels arranged one above the other in a suitable containing vessel. The anodes and kathodes are fixed upon the opposite sides of the funnel walls. The space between two successive funnel walls thus acts as a separate cell.

An electrolyte at 22° B., and a temperature of — 30 to — 38° C. are recommended by the authors. J. B. C. K.

141. *A New Form of Platinum Electrode.* (Electrician, 47. p. 911, Oct. 4, 1901.)—This is designed for competing with platinum in durability and with ordinary carbon electrodes in cheapness, and consists of a thin glass tube, closed at the lower end by fusion, into the walls of which a number of fine platinum wires are fused, to the projecting ends of which strips of platinum-foil 0·8 inch wide and only 0·0003 inch in thickness are attached by autogenous soldering. The connection with the current supply is provided by an equal number of copper strips, which pass down the interior of the tube, and are soldered to the portions of the platinum wires which pass through it. The

upper ends of these wires are soldered to a copper block, to which the electrical connection is made. An electrode constructed in this way, with an active surface of 10·75 square feet, will only require 100 grms. of platinum. The loss of e.m.f. by internal resistance can be reduced to a minimum by using sufficiently thick copper wires to make the connections in the interior of the tube, and by increasing the thickness of these wires the electrode can be used for high current densities. The inventor considers that it will now be possible to use platinum as the electrode material in many electrolytic processes, &c., from which its high price has hitherto excluded it, and that in this new form platinum can even compete in price with carbon. J. L. F. V.

142. *Acker Process for the Electrolytic Production of Alkalies and Chlorine.* **J. B. C. Kershaw.** (Electrician, 48. pp. 20–21, Oct. 25, 1901.) (See also Elektrochem. Zeitschr. 8. pp. 142–148, Oct., 1901.)—This process has for its object the production of chlorine and caustic alkalies from fused chlorides by electrolysis, employing a kathode of fused lead for the absorption of the sodium liberated, forming the subject of a series of patents held by the

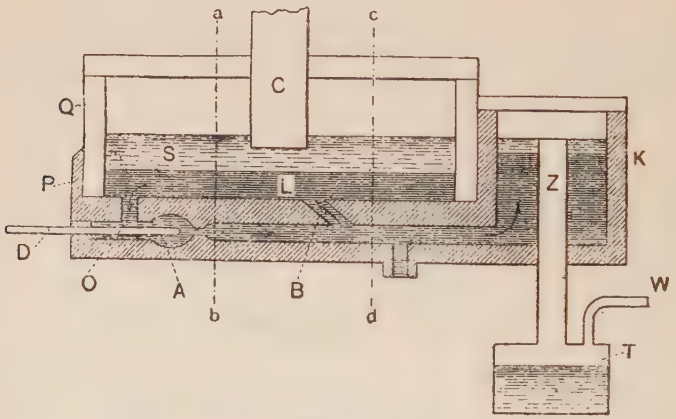


Fig. 1.

Fig. 2. Fig. 3.

Acker Process Company at Niagara Falls. Previous attempts by Vautin and Hulin are mentioned. The principle and action of the cell is best explained by referring to the diagram, Fig. 1.

P is the bottom of the cell, trough-shaped and made of cast iron. It serves as electrical connection between the main conductor and the fused lead resting upon it. The upper portion Q is constructed of refractory material not attacked by chlorine and fused salt, and fits closely into the cast-iron trough. S is the layer of fused salt, and C the carbon anode dipping into it.

The main feature of the cell is the circulation of molten lead-sodium alloy, as indicated by the arrows in the diagram. This is effected by a system of channels, which will be clear from diagrammatic cross-sections through AB and CD (Figs. 2 and 3).

A pipe D, ending in an egg-shaped enlargement at the point A in Fig. 1, supplies steam under pressure, and thus causes circulation of lead-sodium alloy from the cell into the closed chamber K. NaOH and H are here formed, and the molten caustic passes through Z into the collecting vessel. The lead freed from sodium collects in the lower part of K, and continually flows back, through side channels and the opening B, into the bottom of the decomposer, thus acting continuously as a carrier for the Na.

A modification of this apparatus is also explained. The author states that anhydrous caustic soda, 79 per cent., Liverpool test, can be produced by the Acker process, and does not quite agree with the adverse criticism which recently appeared in the Zeitschr. Elektrochem. (*loc. cit.*), although he thinks it wiser to assume that the process is still in the experimental stage of development. O. J. S.

143. *Distribution of Lines of Current in Electrolytes.* **W. Pfanhauser, Jr.** (Zeitschr. Elektrochem. 7. pp. 895–897, Sept. 26, 1901.)—The causes of uneven deposits in electroplating form the gist of this paper. Particular attention is drawn to the thickening of deposits at the edges, and also to the plating of complicated objects and those which have large cavities which require to be coppered or brassed. In such cases auxiliary anodes are required, or special rheostats must be employed for the purpose of adjusting current densities. Formulæ for the distribution of the current lines are also given. Special reference is made to the difficulties in depositing brass, and the necessity of having sodium bisulphite present, in the case of cyanide baths for this purpose. O. J. S.

144. *New Form of Electric Furnace.* **C. Keller.** (Elektrochem. Zeitschr. 8. pp. 156–159, Oct., 1901.)—This furnace differs from other types in the fact that the electrodes form the hearth and sides of the furnace body, which is enclosed in an arched brickwork casing. The electrodes are of carbon, and are mounted on trolleys running on rails. The central electrode forms the hearth of the furnace and is connected to the positive conductor, while the inclined side electrodes are attached to the negative conductor, and form, with the hearth, a trough-shaped furnace body in which the materials to be heated are placed. The electrodes possess a large superficial area, and are made up of large blocks covered and surrounded by a mass of smaller pieces of carbon. Air circulation is used to keep the under-sides of the trolleys carrying the hearth and sides of the furnace cool. The article is illustrated. J. B. C. K.

REFERENCE.

145. *van der Waals' Free Energy Surface for Mixtures of Two Substances.* **C. M. A. Hartmann.** (Journ. Phys. Chem. 5. pp. 425–498, Oct., 1901.)—This paper contains a survey of van der Waals' theory of binary mixtures and of experimental work done in connection therewith. It consists of three parts, of which the first treats of the Ψ-surface and conceptions derived therefrom, reviewing that part of the theory which relates to the first plait of the surface, the second contains the consideration of special questions, while the third is a compilation of all experiments which may be brought into relation with the first plait of the Ψ-surface. W. E. T.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

146. *Triple-Expansion Engines, South Shields.* (Engineer, 92. pp. 398–400, Oct. 18, 1901.)—This paper contains a description of the type of engine supplied by J. and H. McLaren, of Leeds, to work in connection with a 500-kw. alternator. The engine is capable of developing a maximum overload of 1,000 i.h.p. at 125 r.p.m., with a steam pressure of 160 lbs. per square inch; cylinders 19½, 30½, and 48 inches diameter by 24-inch stroke, all steam-jacketed; balanced slide-valves; surface condenser of ordinary type. The steam used is taken direct from boilers of the marine type, without any drying or superheating. A special feature is the speed-regulating gear which is applied to the crank-shaft governor. The normal speed of the engine is 120 r.p.m., but by means of this appliance the governor may be set, while the engine is running, to govern at any desired speed within 5 per cent. above or below the normal.

The following figures are from the results of a trial by W. Hartnell, of one of these engines at South Shields:—

Load	Full	¾	½	¼
kw.	517	390	252	115·4
Steam chest pressure	161·4	164·9	164·7	157·3
r.p.m.	125·3	125·8	125·6	125
i.h.p.	780	637·6	447·5	264·7
Jacket water. Lbs. per hour	587	598	527	276
Total condensed water (jackets and cylinders)	10,440	8,087	5,609	3,455
Total steam per i.h.p. hour. Lbs.	13·44	12 66	12·52	13·03
„ „ kw. hour	20·19	20·7	22·5	29·9

H. R. C.

147. *Test of a Triple-Expansion Engine.* **H. Lorenz.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 649–654, 1901.)—The engine had been working day and night for a year in the Norddeutschen Portland cement factory at Misburg; its normal load is 700 i.h.p., its maximum 900 i.h.p., the cylinder diameters are 475, 750, and 1,200 mm. Two tests were made, one with steam-jacket, the other without. The steam consumption per i.h.p.-hour was in the two cases 5·45 and 5·67 kilos respectively, when working at 600 i.h.p. The consumption was determined by measuring the feed-water, and consequently includes all losses in jackets, &c. The steam consumption in the jackets was 0 80 kilo per i.h.p.-hour. The work done in the intermediate cylinder was not altered by the steam jacket; that done in the high-pressure was diminished, and in the low-pressure increased. The actual figures were, for high, intermediate, and low-pressure cylinders respectively, without steam-jacket, 239·8, 147·7, 210·4—total, 597·8; with steam-jacket, 188·3, 145·7, 265·3—total, 599·3. To obtain greater accuracy in determination of the boiler water level, the author recommends that a curve be plotted between the water level and time, and that the feed-pump be worked either uniformly or at regular intervals. G. H. B.

148. *Engines for large Dynamos.* **C. Day.** (Electrician, 48. pp. 23–26, Oct. 25, 1901. Paper read before the Manchester Association of Engineers, Oct. 12, 1901.)—The author describes the type of engine made by the Ferranti Company. It is a vertical compound engine having the dynamo between the two bearings and the cranks outside ; the engines are completely enclosed, and continuous lubrication is secured by means of an oil pump and filter. The speed of the 1,000 h.p. size is 214 r.p.m. With a view to securing the economy of the slow-speed Corliss engine, the cylinders each have four valves—*i.e.*, steam and exhaust valves at each end ; these valves are of the grid type, and are placed in the cylinder covers, being worked by cams which rotate at half the speed of the engine. The cam-shaft and the whole of the gear for actuating the valve spindles are collected midway between the cylinders, and enclosed in a box which is kept filled with oil. The steam valve spindle is pivoted to the middle of a rocking lever, one end of which is operated by the opening cam and the other by the closing cam ; the angle of advance of the latter is altered by a relay piston controlled by the governor, and thus the point of cut-off is varied to suit the load. The exhaust valve is worked directly from one cam. A test of a 500-h.p. engine at Cardiff electric lighting works gave 15·6 lbs. of steam per i.h.p.-hour, and 24 lbs. per kw.-hour, with a boiler pressure of 140 lbs. and a vacuum of 18·7 inches. An allowance for the bad vacuum of the separate condensing plant reduces these to 13·8 lbs. per i.h.p.-hour and 21·8 lbs. per kw.-hour. H. R. C.

149. *Measurement of Cyclic Irregularity in Engines.* **R. Franke.** (Elektrotechn. Zeitschr. 22. pp. 887–892, Oct. 24, 1901. Paper read before the ninth Jahresversammlung des Verbandes Deutsch. Elektrotechn. in Dresden.)—The cyclic irregularity of an engine is defined as the ratio of the difference between its maximum and minimum velocity in any one cycle, to its mean velocity. The author points out the great difficulties met with in measuring this ratio, the chief being perhaps the continual variation in the mean velocity. He describes Radinger's method of measurement, in which a tuning-fork traces a wavy line on a smoked cylinder attached to the engine shaft ; Göpel made an apparatus on this principle in an improved form, but the method is far from sensitive, and useless for measurement of small irregularities of 1/100 and less. Schäfer and Budenberg's apparatus consists of a disc attached to the engine shaft, and a flywheel turning freely on the same axis ; the disc and flywheel are geared together by a planet gearing, whose axis, perpendicular to that of the wheel carries a pencil point tracing on a rotating drum. The flywheel is turned through the planet gearing, and takes up the mean speed of the engine ; as it is too heavy to follow the cyclic variations in speed of the disc, these cause the axis of the planet gearing to move backward and forward round the axis of the disc, and the pencil point therefore traces a periodic curve on the drum. This curve, however, does not give the difference in velocity, but the relative change in position of the disc and flywheel, and the maximum difference in velocity must be calculated from the two steepest tangents to the curve. This apparatus is troublesome in the calculation of results and is not sufficiently sensitive for small irregularities. Another apparatus is constructed on the principle of Hefner von Alteneck's transmission dynamometer, a pulley attached to the engine shaft being connected by a belt to a flywheel, which takes up the mean velocity of the engine ; the variations in velocity produce variations in the tension on the two sides of the belt, and an index is arranged to measure these. The elasticity of the belt renders this apparatus unsuitable for any absolute measurements. An

apparatus constructed by the author consists of a heavy cylinder, mounted on an axis fixed to the engine shaft by ball bearings ; the friction in these causes it to take up the mean velocity. A frame fixed to the shaft embraces the cylinder, and carries a pencil point which is free to move along a generator of the cylinder. A string attached to the pencil passes over a pulley to a sleeve running free on the axis ; if this be held still, the string winds up on it and pulls the pencil along the cylinder. As the motion of the cylinder is uniform, while the pencil follows the irregularities of the engine, the latter traces a curve, from which the cyclic irregularity can be reckoned. This apparatus was found to work well, but was not sufficiently sensitive for small irregularities.

The only method which the author has found capable of measuring an irregularity of less than 1/100, is to employ a small independently excited dynamo driven by the engine, and take its curve of volts by means of a Joubert contact-maker and potentiometer ; as the volts are proportional to the speed, this gives also the curve of speed of the engine. If there be no irregularities in the dynamo pressure due to its construction, this method is capable of giving very accurate results, but it is troublesome and quite unsuited for practical work.

The author then deals with the effect of cyclic irregularities, more especially with regard to the parallel running of alternators. He considers that in many cases, for instance with gas engines, parallel running is rendered more difficult by the use of heavy flywheels, as the inertia of the engines is then so great that they cannot sufficiently quickly alter their speed in response to the equalising currents in the alternators. He thinks there is no need to attain a smaller cyclic irregularity than 1/200. G. H. B.

150. *Boilers and Engines for Superheated Steam.* **Hunger.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 597–603, 1901. Paper read before the Bezirksverein at Essen, Nov. 14, 1900.)—Scale drawings are given of two boilers with superheaters, and the author in describing them mentions various points to be observed in installing a superheater. Independently fired superheaters are uneconomical, as the gases must be cooled by admixture with air before reaching the tubes.

The author then describes a horizontal tandem compound engine, built for superheated steam, with cylinder diameters of 350 and 600 mm. and stroke of 900 mm. The principal features of the engine are : The high-pressure cylinder is turned perfectly cylindrical on the outside, so that its expansion may be symmetrical, without causing any distortion ; the trip-valve chambers are very massive, and fixed by flanges to each end of the cylinder. The piston is very long, about half the length of the stroke, and has two or three Ramsbottom rings ; the glands have cast-iron rings and asbestos packing. The author recommends that steam mains for superheated steam be given only from $\frac{1}{2}$ to $\frac{2}{3}$ of the section commonly used for saturated steam. Water-traps are very necessary, owing to the excessive condensation at starting, and to the presence in the steam of particles of solid matter from the superheater tubes. The quantity of lubricating oil required is no more than with saturated steam.

Particulars are given of tests made on an old pumping engine, which had been working at 5 atmospheres pressure, and was later supplied with a boiler for 10 atmospheres and superheater. At 5 atmospheres, without steam-jacket, the steam consumption per i.h.p.-hour was 9·44 kilos and with steam-jacket 8·58 kilos ; in the boiler 1 kilo of coal gave 5·66 kilos of steam. At 10 atmo-

spheres, and 286° C. superheat, the consumption was 5·96 kilos per i.h.p.-hour, the boiler giving 5·76 kilos of steam per kilo of coal of 6,300 calories heating value. A 200-h.p. tandem engine showed, with 346° superheat, a consumption of 4·48 kilos per i.h.p.-hour. G. H. B.

151. *Selection of a Steam Boiler.* **W. E. Snyder.** (Street Rly. Rev. 11. pp. 789–790, Oct., 1901. Abstract of a paper read before the Engineers' Soc. of West. Pennsylvania.)—The author gives some useful advice as to the importance of obtaining practical knowledge of the fitness of a boiler design for the special circumstances of its work, and recommends that the following points should be investigated before any boiler is selected:—(1) Safety; (2) convenience of manipulation; (3) steaming properties; (4) durability, and (5) cost. Under the head of Efficiency as a Steam Generator he remarks that the practice of rating the evaporative performance by h.p. is defective, and that the area of heating surface allowed per h.p. should be stated for each boiler, as well as the total efficient heating surface and its distribution. The evaporative results in boilers are proportional to the amount of surface in efficient operation, and not to the total heating surface. Moisture in steam depends more on conditions of work than on design. 1,200 tests of different types of boilers showed in general steam commercially dry or containing less than 2 per cent. moisture, although a boiler on one occasion yielded 8 per cent., and afterwards less than 0·5 per cent. Durability and economy of working generally depend upon facility for cleaning. As the boiler is the heart of the whole installation, its suitability is a vital factor which should not be left to the kind of engineering skill provided by the boiler-making companies. F. J. R.

152. *Combustion of Fuel.* **A. Bement.** (Amer. Electn. 13. pp. 484–486, Oct., 1901.) [See also Abstract No. 1989 (1901).]—In this paper the author describes the construction and use of various forms of apparatus devised for indicating the proportions of CO_2, O, and CO in furnace gases. The instruments noticed are Orsat's, which provides for measuring 100 cub. cm. of gas, and absorbing the various constituents in U-tubes containing suitable reagents; Arndt's "Econometer," which continuously weighs a moving sample of gas after it has been passed through filters and an absorbing tube for removal of moisture, the excess of weight over that of air showing on the scale over which the pointer moves the percentage of CO_2 contained; and the "Composimeter" which reduces the volume of the gas by removing the CO_2, the consequently reduced pressure being indicated by a water column moving over a graduated scale. Hempel's apparatus is also mentioned as suitable for more complete examination of the constituents of gases in laboratory work, but the three first-named instruments can be attached to, and used in, the boiler-room of a central station in order to show whether the combustion of the fuel is being conducted efficiently. Illustrations of the Orsat apparatus and the Econometer are given in the paper. F. J. R.

153. *Tests of Automatic Stokers.* (Eng. News, 46. pp. 345–346, Nov. 7, 1901.)—This article contains the official report of a comparative test of underfeed "American" automatic stokers firing Stirling boilers, and "Roney" stokers firing Babcock-Wilcox boilers at the works of the General Electric Company at Schenectady, N.Y. The report is signed by J. E. Denton, Professor at the Stevens Institute, Hoboken, N.J., F. W. Dean, and G. H. Barrus, the engineers appointed to make the tests in accordance with the standard code of the

American Society of Mechanical Engineers. These tests showed that with coal of an average quality yielding not less than 14,500 B.Th.U. by standard calorimeter, the Stirling boiler with American stoker evaporated 11·889 lbs. gross, or 11·743 lbs. net, water from and at 212° F. per lb. of dry coal, and developed 716 gross h.p., or 705 net h.p., the rated capacity of the apparatus being 517·5 h.p. The Babcock-Wilcox boiler and Roney stoker gave a net evaporation of 11·169 lbs. of water as above.

The cost of fuel per annum in each case, taking coal at $3 per ton of 2,240 lbs., is shown as follows :—

For Babcock-Wilcox boiler—

$$\frac{34{\cdot}5 \times 24 \times 360}{11{\cdot}169} = 26{,}698 \text{ lbs., or } 11{\cdot}92 \text{ tons, costing } \$35{\cdot}76.$$

For Stirling boiler—

$$\frac{34{\cdot}5 \times 24 \times 360}{11{\cdot}421} = 26{,}093 \text{ lbs., or } 11{\cdot}65 \text{ tons, costing } \$34{\cdot}95.$$

The total costs are stated as follows :—

	American Stoker.		Roney Stoker.
Costs per h.p. per annum.	1.	2.	3.
Cost of coal	$34·95	34·95	35·76
„ repairs.....	0·77	0·12	0·48
Wages of firemen and helpers	1·44	1·44	1·44
Interest and depreciation	0·38	0·38	0·38
Total cost	$37·54	36·89	38·06

Column No. 1 gives repairs according to three months' record in log-book. Column No. 2 gives repairs guaranteed in contract. F. J. R.

154. *Modern Power-house.* **J. H. Vail.** (Street Ry. Journ. 18. pp. 478–479, Nov., 1901. Paper read before the Amer. Street Rly. Association.)—Steam-engine efficiency having reached practically the highest point, additional economies must be sought in accessories. The author proposes a combination of the use of pulverised fuel, superheated steam, and cooling towers for condensing. The first two have been investigated in cement works and at Milwaukee [see Abstracts Nos. 2231 and 2232 (1901)]. Regarding the third [see Abstract No. 1985 (1901)], the author quotes special experience with the Twenty-sixth Street station of the New York Edison Company, which was designed by him in 1887 and started in 1888. The maximum equipment was limited to 2,600 h.p., with the best selection of apparatus then obtainable. Now, however, with the originally designed boiler capacity, the maximum capacity has been increased to 6,000 h.p., through improved engines and dynamos, with the application of a cooling tower and condenser system.

Upwards of five hundred cooling-tower installations exist, ranging in capacity from 250 to 12,000 h.p., the results being in most cases excellent. Results from the open cooling tower at the Plainfield, N.J., power station during July, 1901, are quoted, showing an average vacuum of 25·17 inches and 30° average reduction of temperature of condenser water. With the fan type of cooling tower results show that with an atmosphere temperature of 96° F. and condenser discharge of 130°, 37° of heat were extracted and a vacuum of 24½ inches obtained by passing the water through the tower. A

fan tower is also used at Plainfield, extracts from the log of which are given. The author advocates giving a liberal margin of capacity in such installations, because a heavy load may come on under adverse atmospheric conditions. The cooling water should be estimated at not less than thirty times the steam consumption of the engine, and two thousand times more air than water will be required. The degree of heat extracted from the water by passing through the tower is affected by atmospheric temperature, humidity, &c., but actual results show a range of from 30° to 50° F. reduction of temperature, and a vacuum of 23 to 27 inches is readily obtained. There will sometimes be 1 to 3 per cent. loss of water due to evaporation in the tower, but when the circulating water is kept separate from the boiler feed, that can be made up at slight cost. F. J. R.

155. *Purification of Boiler Feed-water.* (Mech. Eng. 8. pp. 549–554, Oct. 26, 1901.)—This is a summary of a section of C. E. Stromeyer's memorandum as chief engineer, to the annual meeting of the Manchester Steam Users' Association. Nine of the principal processes in use for softening calcareous waters were inspected by the chemist of the Association. All the processes are based on the use of lime-water, or milk of lime, for the removal of temporary hardness, and of sodium carbonate for permanent hardness. Most of them are continuous in action, only one of those described being intermittent. The precipitation of the lime salts, and especially of the calcium sulphate, being slow, the different processes exemplify various methods of overcoming the inconvenience of having large settling tanks or of employing filters. These methods are classified as follows :—(1) The treated waters are mixed with old sediment. (2) They are mechanically stirred. (3) They are stirred by air-jets. (4) They are heated. (5) After having settled, the nearly clear fluid is treated with carbonic acid, which dissolves the remaining sediment. The reporter considers 1 and 2, if used with filters, to be fairly satisfactory, but does not favour the use of baffle-plates in the settling towers. He thinks heating, as in 4, expedites the chemical action and the deposit of scale-forming material, but points out that the heating should take place before and not after purification. Nos. 3 and 5 are objected to on account of their charging the water with corrosive agents. Installations of the following systems are described :—The Porter-Clark continuous water-softener, the Stanhope, the Atkins, the Tyacke, the Wollaston, the Brunn-Lowener, the Desrumaux, and the Reisert processes and apparatus, which are all continuous in action, and the Archbutt-Deely system, which is intermittent.

Diagrammatic representations of the various apparatus are given, and also a few chemical analyses of waters before and after treatment. F. J. R.

GAS AND OIL ENGINES.

156. *Acetylene Motors.* **H. Cuinat.** (Locomotion Automobile, 8. pp. 616–618, Sept. 26, 1901. From *La Chronique Industrielle.*)—Some figures are given relating to the properties of acetylene, and also the results of actual experiments on motors using this gas. An engine tested in 1896 with acetylene gas in the proportion of 1 gas to 20 air, developed 6 h.p., with a consumption of 175 litres of gas per h.p.-hour. The same engine consumed 516 litres of ordinary lighting gas per h.p.-hour at the same power. With acetylene the compression pressure was 8 kg., and the explosion pressure 29 kg. per sq. cm. In the case of a 3-h.p. Otto engine tested by the "Gas

Motoren Fabrick Deutz," the consumption of gas per h.p.-hour was 225 litres at 15°C. The compression pressure was 12·59 kg., the explosion pressure 43·6 kg., and the final pressure on exhaust 3·87 kg. per sq. cm. The proportion of gas and air varied from 1 to 25 to 1 to 30. C. R. D'E.

157. *Methods of Increasing the Power of Petrol Motors.* **G. Lavergne.** (Locomotion Automobile, 8. pp. 609–610, Sept. 26, 1901.)—The author points out that in 1895 the de Dion motor weighed about 36 kg. per h.p., and in 1900 the weight per h.p. for the same type of motor had been reduced to 9·4 kg. The 16-h.p. Buchet motor for the No. 5 Santos Dumont flying machine weighs 5·8 kg. per h.p. The following means of augmenting the power of motors are pointed out :—Adding oxygen gas to the explosive mixture ; increasing the size of the silencer, and so reducing the loss due to back pressure on exhaust ; increasing the pressure of compression, which at present varies from 2·5 to 5 atmospheres, and might possibly be increased to 7 atmospheres with advantage ; increasing the speed of rotation, which is limited by the fact that the velocity of the piston must be considerably less than the velocity of inflammation of the explosive mixture. Buchet finds in practice that the limit of piston velocity is between 4·5 m. and 5 m. per second. With higher compressions the piston's velocity might be increased. C. R. D'E.

158. *Alcohol Motors.* **L. Perissé.** (Locomotion Automobile, 8. pp. 625–626, Oct. 3 ; 641–642, Oct. 10 ; 657–659, Oct. 17 ; and Discussion by **A. Lecomte,** pp. 673–674, Oct. 24 ; and pp. 705–706, Nov. 7, 1901.)—The author opens this series of articles by pointing out the advantages which alcohol possesses in being a fixed and homogeneous chemical compound. Alcohol can now be obtained commercially in an almost chemically pure state. It possesses the advantage over petrol that it can be made and used in any climate. In France what is known as *pure commercial alcohol* has the following composition : Ethyle alcohol (90 per cent. rectified), 100·0 litres ; methyle alcohol (90 per cent. rectified), 10·0 litres ; heavy benzine (distilling between 150°–200° C.), 0·5. In order to increase the calorific value and decrease the price of this alcohol it is carburetted with light benzine, which boils between 80°–120° C., the mixtures usually employed for motors containing either 25 per cent. or 50 per cent. of the latter. The heats of combustion per kilogramme of the *pure commercial alcohol* and of these two mixtures are 5,111, 6,159, and 7,145 calories respectively. The price of pure commercial alcohol varies from 0.55 fr. to 0.60 fr. per litre, and that of carburetted alcohol is 0.45 fr. per litre. Various forms of carburettors for alcohol motors are mentioned, amongst those most frequently used being the spray-making carburettors of Longuemare [see Abstract No. 1144 (1900)], Martha, and le Blou [see Abstract No. 900 (1900)]. Certain figures are given, obtained from the results of three contests between motor vehicles employing alcohol held in France during 1901. At Deauville the mean speed for the flying kilometre was at the rate of 81·810 km. per hour for carburetted alcohol, and 76·200 km. for pure alcohol. With a 20-h.p. Darracq car the speeds obtained for the flying kilometre were 90 km. per hour with petrol, 81·8 km. per hour with carburetted alcohol, and 65·45 km. per hour with pure alcohol. The author comes to the conclusion that in motors employing alcohol the ratio of the length of stroke to the bore of cylinders and the compression should both be as great as possible.

Some figures are given relating to vehicles for heavy goods, propelled by alcohol motors, which took part in certain trials between Paris and Achère

(25 km.). The lorry of the "Société naucéenne d'automobiles," Brillié system, which weighed 2,500 kilos empty and carried a load of 3,377 kilos, travelled at an average speed of 8·7 km. per hour and consumed 0·095 litre per tonne-km. of total load, the alcohol being carburetted with 50 per cent. of benzine. The engine was of 10 h.p. with two vertical cylinders each with two pistons. The de Diétrich and Panhard Levassor lorries also gave good results. Amongst the lighter vehicles the 6-h.p. Panhard Levassor vehicle, weighing 990 kilos empty and carrying 913 kilos, consumed 0·098 litre per tonne-km. of this mixture. As a result of certain trials held in Germany of an alcohol motor-lorry the following figures are given :—Weight of vehicle and load, 3,242 kilos ; useful load, 1,092 kilos ; daily journey during seven days, 36·85 km. ; consumption of alcohol carburetted with from 20 to 25 per cent. of benzine, 0·107 litre per tonne-km. of total load. C. R. D'E.

159. *Coolers.* (Locomotion Automobile, 8. pp. 587–588, Sept. 12, 1901.)—Two forms of water-coolers for internal combustion engines are illustrated and described. The first is intended for use on a motor tricycle, and consists of a combination water, petrol, and oil tank of corrugated metal, together with a length of corrugated tubing attached below the tank. The second form consists of a shallow hexagonal tank pierced by numerous tubes, through which air is sucked by a fan driven by the motor. C. R. D'E.

160. *Kécheur Carburettor.* **P. Sarrey.** (Locomotion Automobile, 8. pp. 582–583, Sept. 12, 1901.)—This carburettor is of the type in which the suction of the motor cylinders raises a light spring-controlled valve, which closes both the main air supply and the petrol jet. The injected petrol runs down the exterior walls of a chamber which is heated by the exhaust gases, and the vapour mixes with the indrawn air, which also passes around the heated chamber, and thence to the motor cylinder. A sectional elevation is given. C. R. D'E.

AUTOMOBILISM.[1]

161. *The Design of Automobiles.* **W. A. T. Müller.** (Centralblatt Accumulatoren, 2. pp. 221–224, Aug. 15 ; 235–239, Sept. 1 ; 245–249, Sept. 15 ; and pp. 257–260, Oct. 1, 1901.)—These articles continue the discussion of the general principles underlying the design of automobiles. The first two articles contain a further examination of the connection between tractive effort and the diameter of the wheels, the author arriving at a formula which corresponds almost exactly with that given in Abstract No. 1386 (1901). All authorities agree that the coefficient of rolling friction is less with wheels of large than with those of small diameter ; but there is difference of opinion as to the precise relation between the tractive effort, the load to be drawn, the diameter of the wheel, the width of tyre, &c. [See also Abstract No. 587 (1901).] The author, however, points out that the vibration of the vehicle tends to increase the tractive effort necessary, and that the latter does not depend directly on the load drawn. For instance, a car weighing 2,050 kg., took 44 amperes at 75 volts on the level, when carrying one person. If the load was increased to six passengers, *i.e.*, by 18 per cent. of the whole, the current increased by rather less than 1 ampere ; and this cannot be explained by any of the formulæ proposed. A mathematical consideration

[1] Electric Automobiles are described in the Section dealing with Electric Traction.

of the question leads the author to the conclusion that the loss of energ through shocks is inversely proportional to the diameter of the wheel. H practical conclusions are as follows:—(1) That the wheels should have larg diameters; (2) that the wheels and axles should be as free as possible fro any of the working mechanism; (3) that the car springs should be s constructed as to undergo a considerable deformation with a slight increas of load; and (4) that the upper part of the car together with all it appurtenances should be rigidly connected together. W. H. S

162. *Testing Power Losses in Motor Cars.* **P. Gasnier.** (Ind. Élect. 10 pp. 469–471, Oct. 25, 1901.)—After criticising the methods employed i recent trials of the efficiency of motor cars, *i.e.*, of the ratio of the powe available at the rim of the wheel to the power at the motor spindle, a description is given of a new method which will obviate any necessity fo determining sundry small losses. The author proposes to have an endles moving platform on to which the car to be tested will be driven with all its passengers. The car is held to a rigid support by a spring balance and the wheels work the moving platform. Any desired surface can b imitated by putting more or less brake, mechanical or electrical, on to th moving platform. It is only necessary to read the spring balance and th speed of the platform, or of the wheels, in order to determine directly th power at the rims of the wheels. The effect of the car's kinetic energy i making the engine run steadily might be imitated by moving the whol apparatus at a speed corresponding to the speed of the car wheels. Carefu tests of an electric car on such an apparatus, with different wheels, tyres &c., might accurately determine the coefficients of traction, and the effect o different tyres and various wheel diameters, as to which the present dat are very vague. E. H. C.-H

163. *House Steam Car.* (Automotor Journal, 5. pp. 586–588, Sept., 1901.)— This is a four-seated pleasure vehicle, with the mechanical parts all carefull enclosed and the boiler almost completely out of view within the carriag body. The boiler is of the vertical fire-tube type, 20 inches diameter b 16 inches high, and is fired by a liquid fuel burner consuming ordinar petroleum. The working pressure is 250 lbs. per square inch. The engin is of the horizontal compound type, but special arrangements are fitted fo using, when desired, full pressure in the l.p. cylinder, and the transmissio mechanism consists simply of a single spur gear from the crank-shaft to th exterior of the differential gear on the rear, or driving, axle. The casing enclosing the engine and gearing, is attached to the tube surrounding th rear axle, and the front end of the engine is slung from the underframe by single pivoted tie-bar, which allows the whole mechanism to play up an down with the axle. The weight of the vehicle unloaded is 16 cwt. Th paper is illustrated by photographs. C. R. D H

164. *Yorkshire Steam Motor Waggon.* (Automotor Journal, 6. pp. 10–1 Oct., 1901.)—In this waggon the boiler is mounted at the front of a chann steel frame, and the engine cylinders are mounted at either side of the fram below the waggon body. The transmission from the crank-shaft to th driving axle is by spur gearing throughout.

The boiler consists of a cylindrical drum, at the centre of which, and pr jecting below it, is the fire-box. At either end of the drum are smoke-box connected by fire tubes to the fire-box. From these smoke-boxes tubes pa

back to a central smoke-box above the fire-box, and the products of combustion escape thence through a vertical chimney. The doors of the end smoke-boxes contain chambers for receiving the exhaust steam, and the steam escapes thence by nozzles which project into the tubes connecting the end and central smoke-boxes. The boiler is mounted with the length of the drum transverse to the length of the waggon frame. The engine crank-shaft is mounted in bearings on the waggon frame, and lies parallel to, and in front of the rear axle; the cylinders being at either side, outside the frame, and the pistons coupled to cranks at the ends of the crank-shaft. The transmission is first by spur gearing to a counter-shaft carried in bearings on side brackets pivoted from the underframe; the arrangement being such that the radial distance between axle and counter-shaft, and counter-shaft and crank-shaft, are kept constant. The counter-shaft then drives the axle by a pinion, gearing with a spur wheel mounted upon the differential gear. C. R. D'E.

165. *Wolseley Motor Car.* (Automotor Journal, 6. pp. 6–7, Oct., 1901.)—In this vehicle a horizontal double cylinder petrol engine is mounted at the front end of a channel steel underframe, with the cylinder centres slightly below the frame level, and the crank-shaft lying at right angles to its length. The transmission from the crank-shaft to the rear wheels is effected, firstly, through a cone clutch and a Renold's chain drive to the change-speed gear, and thence by independent roller chain drives to the wheels. In the change gear four speeds forward and one reverse are obtained by means of spur wheels and pinions brought into engagement by side contact, and the differential cross-shaft of the change gear carries at either end the sprocket pinions of the final chain drives. The front portion of the frame is covered by a bonnet the sides of which are surrounded by the tubes of the radiator for cooling the cylinder jacket water. At its back end the bonnet abuts against the dashboard. The petrol tank is enclosed within the bonnet and attached to the front of the dashboard. The underframe is attached by single plate springs to the axles. Wheels of equal diameter front and back are employed. The steering wheels are pivoted on the Ackerman system, and their direction is controlled from a hand-wheel which operates through a bevel and a worm gear. A band-brake on the differential cross-shaft and powerful shoe-brakes acting on drums attached to the rear wheels are provided. C. R. D'E.

166. *"Roze" Flying Machine.* **G. Jougla.** (Locomotion Automobile, 8. pp. 566–568, Sept. 5, 1901.)—This machine consists of two cigar-shaped balloons, parallel and in a horizontal plane, joined by a framework of aluminium tubes, which carries the operator, the motor, and four propellers, two for lifting the machine and two for propelling it horizontally. The balloons are each 45 m. long × 7 m. in diameter, with a double silk envelope mounted upon a skeleton frame of aluminium tubes. The power is supplied to all the propellers by a 20-h.p. Buchet motor with four water-cooled cylinders. The propellers are each 3·20 m. in diameter, and can be driven simultaneously at 250 r.p.m., or either pair alone at 300 r.p.m. It is calculated that the total weight of the machine will be 2,500 kg., or about 70 kg. in excess of the lifting power of the balloons alone. Steering is effected by a rudder suspended at one end of the central frame. C. R. D'E.

GENERAL ELECTRICAL ENGINEERING.

167. *Halsey Direct-current Meter.* (Elect. World and Engineer, 3
pp. 231–232, Aug. 10, 1901.)—The meter consists of a copper drum
disc rotating in mercury between the poles of a permanent magnet, t
current entering and leaving the mercury path at two points so placed th
it passes across the field. Several forms of the meter are described an
illustrated. No compensation for friction is provided, as a 25-ampere met
starts with $\frac{1}{10}$ of an ampere, and is only 10 per cent. slow on $\frac{1}{4}$ of a
ampere. Variations in the strength of the permanent magnet do n
materially affect the constant. G. H.

168. *Rotary Field Measuring Instruments.* **F. Schrottke.** (Elektrotechn
Zeitschr. 22. pp. 657–667; Discussion pp. 667–669, Aug. 15, 1901. Pape
read before the Elektrotechn. Verein, Jan. 22, 1901.)—The author describe
in full detail the Siemens and Halske alternate-current meter with rotat
field [see Abstract No. 1559 (1900)]. The phase-difference of 90° is obtaine
as follows:—The two pressure windings form opposite arms in a Wheatston
Bridge connection, the other two arms being non-inductive resistances
one diagonal is connected across the mains through a choking coil, an
the other joined up by a non-inductive resistance. By adjusting this resis
ance, the current in the pressure windings can be brought into quadratur
with the pressure. As the choking coil takes up the greater part of th
pressure, the arrangement does not require coils of high resistance. Th
loss in the pressure circuit at 120 volts is 1 watt. The auxiliary turnin
moment to compensate for friction is produced by niches in the iron co
opposite the pressure coils; these niches produce a dissymmetry in the fiel
due to the pressure coils, and a consequent increase or decrease of turnin
moment according to the position of the niches relative to the coils. The co
can be rotated by a lever held by two screws, and by these the compensatin
torque can be adjusted from the outside of the case. To avoid running o
open circuit the drum has three or four cuts made on its lower edge; it the
places itself so that the induced current is a minimum and requires a certai
force to move it from this position. The lower bearing of the moving syste
is supported on a spring which is kept in vibration by a small electromagnet
this avoids starting friction, and prevents a change in the constant when th
meter is subjected to outside vibration. The change in the constant due
variations of frequency is very small, and the meter reads accurately on i
ductive circuits up to 75° lag. A meter was shown accurate to within 1 p
cent. from 1 per cent. to 130 per cent. of full load, and starting at 0·2 per ce
of full load. For three-phase currents two meters are mounted with o
moving system; the current field is made to lag about 30° behind the curre
by means of a short-circuited winding, so that the lag of the pressure curre
behind the pressure can be made 90°, a lag entailing less loss of energy in
production than one of 60°.

The author then describes indicating instruments constructed on the sam
principle as the meter, but with a controlling spiral spring. The scales a
given any desired form by combining a gravity control with the spring.
ohmmeter is made, consisting of a voltmeter, one winding of which is co
nected across the mains, and the other between one main and a two-w

switch, connecting either to earth or to the line to be tested, which is connected also to the other main. When the switch connects to earth the instrument indicates the insulation-resistance at normal pressure; with the switch in the other position it indicates the pressure; if this differs from the normal a correction must be applied.

The current transformers for large currents are constructed in a novel way to avoid the influence of outside fields. The bar carrying the main primary current is bent to a U shape, with its plane at right angles to it; the iron circuit is EƎ-shaped, the middle bars passing through holes in the U-legs, and forming the core of the secondary coil. With this arrangement no current would be induced in the secondary, but a dissymmetry is produced in the primary circuit by cutting away portions of the U on opposite sides on the two legs, and it then magnetises the iron circuit. The secondary circuit is then secure from induction by any conductors outside the iron circuit. High-tension transformers for instruments are insulated entirely by porcelain; the primary is wound on a porcelain tube, provided with ridges, forming separate channels which subdivide the winding, and the whole is enclosed in a porcelain case, and filled with insulating material run in in vacuo.

Discussion.—**Benischke** referred to the form of current transformer adopted by the Allgemeine Elektrizitäts-Gesellschaft, which can be fixed round the main conductor itself, without cutting it. **Dolivo-Dobrowolsky** mentioned methods of obtaining a current in quadrature with the pressure other than that described by the author. G. H. B.

169. *Magnetic Brakes.* **K. Feussner.** (Elektrotechn. Zeitschr. 22. pp. 608–611, July 25, 1901. Paper read before the Elektrotechn. Verein, April 23, 1901.)—The author, after pointing out the need for a more accurate form of measuring brake than the Prony, describes two forms of magnetic brakes which have been in use at the Reichsanstalt for testing small motors. In each form a copper disc is mounted on a shaft, and two electromagnets embracing the disc are fixed to a frame which is hung on knife-edges, and provided with a scale-pan for weights. The rotating disc exerts a force on the magnets, which is counteracted by the addition of weights in the scale-pan, till the magnet frame is brought back to zero, as indicated by a pointer. The load is varied by varying the exciting current of the electromagnets. The copper disc is made hollow and water circulated through it by centrifugal force for cooling. The author then deals with the theory of the brake, and shows that the reaction of the induced currents on the magnet field plays an important part. Were there no reaction, the torque exerted by the disc would increase proportionately with the speed, instead of which it diminishes. Of the two brakes used by the author, one showed an increase and the other a decrease of the torque as the temperature, and consequently the resistance, of the disc increased. G. H. B.

170. *An Electric Tachometer.* **É. Hospitalier.** (Ind. Elect. 10. pp. 519–520, Nov. 25, 1901.)—A condenser of capacity C is alternately connected to a battery of e.m.f. E, and discharged through a very dead-beat moving coil voltmeter, by means of a contact on the shaft whose speed is to be measured. If ω is the frequency of charge and discharge, the mean current is $I = \omega CE$. At high speeds the impedance of the voltmeter may prevent the condenser from discharging completely. This may be overcome by using a suitable voltmeter, but it then requires either a large capacity or high e.m.f. Where only low volts are available a transformer may be used, the secondary

being connected to the voltmeter. The voltmeter circuit is both closed a broken just before the primary circuit, so that the voltmeter only takes current due to closing the primary circuit. R. B.

171. *High-Tension Fuses.* **G. Semenza.** (Elettricità, Milan, 20. pp. 48 489, Aug. 3; and pp. 499–500, Aug. 10, 1901. Paper read before the Mil branch of the Associazione Elettrotecnica Italiana.)—The author describ the various forms of high-tension fuses now in use. Of those in a he prefers the type in which the fuse wire is enclosed in a tube open the ends, so that the expansion of the air blows out the arc. When used f large currents the amount of metal vaporised is considerable, and the vapo cloud may cause the formation of an arc between the fuse-blocks. Th having frequently occurred in the Paderno installation, the author substitute fuses immersed in oil, and found them in every way more satisfactory. Th size of wire for the same fusing current is less in oil than in air, and it of decided advantage to reduce the amount of metal to be fused. Coppe however, is not suitable, owing to its high temperature with a normal workin current. Of pure metals tin was found to have the lowest temperature fo a working current taken as a given fraction of the fusing current. A lead-ti alloy of equal parts is still better in this respect, but alloys have the disadvantag of uncertainty in their fusing-points. The ratio of the maximum workin current (for a given temperature of the wire) to the fusing current may b increased by the use of heavy oils, such as ordinary cylinder oil. The autho has employed fuses in vertical tubes filled with oil on 14,000-volt circuits an obtained satisfactory results. G. H. B

172. *Blow-out for High-frequency Arcs.* **A. Soulier.** (Ind. Élect. 1 p. 458, Oct. 10, 1901.)—A description of d'Arsonval's arrangement for pre venting the formation of the arc which is apt to form at the spark-gap of high-frequency apparatus. A small motor has fixed on its spindle an ebonit sleeve to which are attached, in line with each other and with the axis of th spindle, two insulated metal blocks. Through these pass, parallel with eac other and perpendicular to the motor spindle, two metal rods terminated b balls, between which the discharge passes. The metal blocks are connecte [presumably by means of brushes] with the terminals of the high-tensio winding of the induction coil or transformer, and with those of the condense When the apparatus is at work, the displacement of air produced by th rapid rotation of the spark-gap is sufficient to blow out each spark as it passes Incidentally the balls are kept cool, and the deterioration of their surfaces b the spark is retarded. The motor need not absorb more than 30 or 40 watt B. P. S

173. *Lightning Protectors.* **R. Börnecke.** (Zeitschr. Elektrotechn., Wie 19. pp. 478–482, Oct. 6, and pp. 489–494, Oct. 13, 1901.)—The author discusse the various devices which have been used for the protection of cables agains abnormally high p.d.'s due to resonance effects; such devices generall consisting of adjustable spark-gaps, connected on one side to the conductor and on the other side earthed through high non-inductive resistances, co sisting of incandescent lamps or water resistances. He then considers ris of potential due to atmospheric disturbances, and classifies the different form of lightning protectors into a number of groups. An illustrated description various typical forms is given. The diameter of the earth wire is generall

not less than 6 mm. As each additional lightning protector increases the chances of interruptions in the supply, it is desirable to limit their number as far as possible. A. H.

174. *Size of Cell Switch Leads.* **E. Hunke.** (Elektrotechn. Zeitschr. 2. pp. 1006–1010, Dec. 5, 1901.)—This is a mathematical investigation of the most economical size to give to the leads from the regulating cells of a battery of accumulators. Formulæ are deduced for the best current density in terms of the energy cost, price of copper or aluminium, the number of daily charges and discharges, the number of cell leads, and sinking fund and interest. Curves with the main variables are plotted. The influence of rate of change of voltage is minutely examined, according as the cells are charged or discharged. The limits of the calculations, using German prices, vary from about 0·2–1·8 square millimetres per ampere. W. W. H. G.

175. *The Construction of Electromagnets.* **A. J. Conor.** (Électricien, 2. pp. 344–348, Nov. 30, 1901. A paper read at the Association des Ingénieurs de l'Institut industriel du Nord.)—It is a summary of the chief laws useful in the design of electromagnets, which latter are divided into two classes: (1) Electromagnets with armature in contact, and (2) those pulling from a distance (*à grande course*). In the first case the formula—

$$B = 4965 \sqrt{\frac{F}{S}} \text{ gauss,}$$

where B is the induction and *s* the area of cross-section in sq. cm., F being the traction in kilos. is useful. For the other case attention is directed to the method of Guénée [see Abstract No. 234 (1901)]. W. W. H. G.

176. *Electrically Operated Locks on the Dortmund-Ems Canal.* **Rudolph.** Zeitschr. Vereines Deutsch. Ing. 45. pp. 1009–1017, July 20; and pp. 1405–1414, Oct. 5, 1901.)—There are two electrically operated locks on this canal, the one at Münster and the other at Gleesen. The former is described in this article. The fall of water varies from 6·7 m. to 4·4 m., and is utilised to drive a turbine giving 11 h.p., which in its turn drives a 7-kw. dynamo; this furnishes current for the various motors. A small battery of accumulators is also provided. In case of failure of the electrical apparatus the machinery of the locks is capable of being worked by hand. A large number of drawings are given, showing the way in which the motors are geared to the working parts, and the system of control adopted. The lock is 67 m. long, 7 m. deep, and 8·6 m. broad, and is provided with auxiliary side basins to allow for the economical use of water. The time required for working the lock is about 165 seconds, and the energy consumed is on an average 278 watt-hours, including lighting, &c. The amount of water taken by the turbine is 1·4 per cent of the amount required for the working of the lock. W. H. S.

177. *Electrically Driven Pumps at Horcajo.* **F. Heerwagen.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1549–1559, Nov. 2, 1901.)—The mine of Horcajo is in the Spanish province of Ciudad Real, and, since 1855, has been noted for its silver containing lead ore. The presence of water has always necessitated pumping, and the original machinery has now been replaced by high-pressure centrifugal pumps made by Sulzer, which are directly connected to three-phase motors. The electrical plant has been supplied by

Brown, Boveri & Co. The generators are 20-pole machines, with an excite on the same axis, which give 1,000 volts at 270 r.p.m. The output is 300 h.p. with a power-factor of 0·8 the efficiency is 93 per cent. Three more alter nators of the same kind, but of 400 h.p., have lately been added. They ar all driven by Sulzer engines. The motors are six-pole, and give 250 h.p. a about 900 r.p.m., with an efficiency of 94 per cent., the power-factor being 0·8 They are directly supplied at 1,000 volts. The working of these motors ha proved extremely satisfactory. No difficulty has been experienced at starting and there has been no trouble with respect to insulation. Current is supplie by steel-armoured, lead-covered cables supported on the walls of the shaf The article is illustrated by many plans and diagrams, and well deserves th attention of engineers who are considering methods of lifting water fro deep mines. W. W. H. C.

178. *Travelling Crane.* **A. Kolben.** (Zeitschr. Vereines Deutsch. Ing. 4 pp. 1513–1519, Oct. 26, 1901.)—The author describes very fully with numerou illustrations and scale diagram, an electrically driven travelling crane, thre of which are in use in a steel foundry in Kladno. The crane is driven b three-phase current at 500 volts and 25 ∿ and has a span of 11 metres an a capacity of 10 tons. G. H. B.

179. *Electric Travelling Cranes.* (Elect. Rev. 49. pp. 891–893, Nov. 2 1901.)—Particulars are given of the construction of a motor-driven travellin crane, built by Adamson. The overall efficiency of the hoisting motion of 10-ton crane is said to be 43 per cent., and figures are given showing th results of the tests on this and other cranes. W. H. S.

180. *Brakes for Cranes.* **A. Ernst.** (Zeitschr. Vereines Deutsch. Ing. 4 pp. 1081–1087, Aug. 3; and pp. 1123–1129, Aug. 10, 1901. Paper read befor the Würtemberg section of the Verein Deutscher Ingenieure.)—The greate portion of the paper refers to various forms of mechanical brakes. Th latter part, however, contains information as to the working of the Schucke controller, as applied to cranes built by that firm. The usual diagrammati sketch of the connections is given, and it is also described in the Germa Patent No. 120073. The main point is as follows:—the series-wound moto is converted into a generator, which is first short-circuited on itself and the gradually made to discharge through an increasing resistance, the starting resistance being used for this purpose. Provisions are made by which, in th first stage, the motor is run as a shunt motor, the field and armatur windings being thrown into parallel, placed in series with the starting resistance, and fed with the supply voltage. The falling load and the suppl voltage increase the speed to such an extent that the motor is almos instantaneously converted into a generator; the motor circuits are the disconnected from the supply mains, after which it is worked as a seric dynamo, the current generated in the armature being kept within limits b the insertion of a smaller or larger portion of the starting resistance.

W. H. S.

181. *Solenoid Drills for Hard Stone.* **E. Heubach.** (Zeitschr. Vereine Deutsch. Ing. 45. pp. 1492–1497, Oct. 19, and pp. 1526–1531, Oct. 26, 1901.)— This article summarises the principles on which solenoidal percussive roc drills have been built, notably by van Depoele, who used a combination o three solenoids surrounding an iron core, the centre one being excited by

continuous current, and the two end ones by an alternating current, the latter being derived, with a suitably low period, from a continuous-current dynamo, by a pair of brushes revolving on the commutator with a speed governing the period. The more modern construction by Marvin, using two solenoids alternately energised, and the special dynamo for use with this type of drill are described. The method of obviating the difficulties of insulation by mica insulated coils of wire of square section is described. In the second part the electrical working is discussed, and the current and power-factor with various lengths of stroke of the drill are shown by means of curves. The method of winding multipolar generators to give a number of periods, that is of oscillations to the drill, equal to or greater than the number of revolutions of the machine, is described and illustrated. Tables are given of actual results as to speed of working, and cost of wages and sundries extending over a year in 1895, and again in another case for a year in 1899. In conclusion, a comparison of weight and power is given and the respective merits of percussive drills driven by a motor and flexible shaft, with those of the solenoid type are discussed. Ll. B. A.

182. *Electric Power in Coal-mines.* **W. Habermann.** (Zeitschr. Elektrotechn., Wien, 19. pp. 409–413, Aug. 25; and pp. 466–471, Sept. 29, 1901. Paper read before the Elektrotechn. Verein, May 1, 1901.)—The paper deals with the application of electric power to pumping, boring, hoisting, and other machines used in coal-mines, with the amount of power required by the different machines, and with the central supply station. G. H. B.

183. *Becker Electric Furnace for the Manufacture of Glass.* **Bermbach.** (Elektrochem. Zeitschr. 8. pp. 121–128, Sept., 1901.)—The author, in this lengthy paper, gives details of the present methods of glass manufacture, and states that the consumption of fuel per kg. of finished glass varies from 0·50 kg. in the best type of regenerative gas-fired tank furnace, to 4 kg. in the case of direct hand-fired pot furnaces. In the latter a thermal efficiency of only 18 per cent. is obtained, for thermal calculations show that the calories necessary to produce 1 kg. of melted glass only amount to 746. The thermal efficiency of the regenerative furnaces is stated to be 42 per cent. The experience gained with carbide furnaces has, however, proved that 75 to 80 per cent. of the energy of the electric arc can be utilised for direct heating in suitably constructed furnaces, and therefore it should be possible to produce 1 kg. of melted glass, with a coal consumption of 1·5 kg. in an electric furnace of suitable design.

The possibility of applying the electric furnace to glass manufacture is therefore, in the author's opinion, favourable, for many varieties of glass cannot be produced in the large tank furnaces, and the fuel consumption in gas-fired pot furnaces per kg. of glass produced, is about the same as that calculated for the electric furnace.

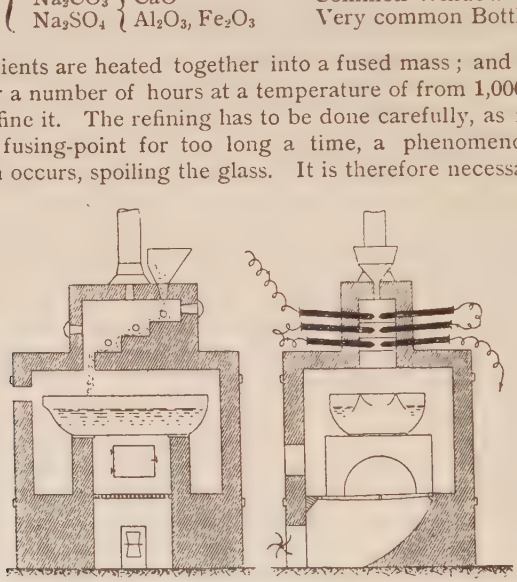
Further, the heavy expenditure involved in the erection and repairs of gas furnaces would be avoided, and a longer life might be expected for the electric furnace. Four illustrations are given, showing two types of Becker furnace.

The principle of these furnaces is—to heat the raw materials, lime, sand, and soda, between successive pairs of carbon electrodes, as they slide down an inclined passage into the furnace body, and to complete the heating of the glass, in the latter, either by resistance heating or by gas-firing. As glass in the molten state is an electrolyte, only alternating current can be used for the latter. A 40-volt current suffices for the arc heating. J. B. C. K.

184. *Experiments in Producing Glass by Electricity.* **M. du Welz.** (Assoc. Ing. Él. Liège, Bull. 1. pp. 173–191 ; Discussion, pp. 191–192, Sept. 21, 1901.)—The author gives an account of experiments made by M. Jules Henrivaux in the utilisation of an electric arc for manufacturing glass. In the first place reference is made to the raw materials employed in making various species of glass, as shown by the following table :—

SiO_2	K_2CO_3	CaO, Pb_n, O_m	Bohemian Glass. Crystal Flint Glass.
	Na_2CO_3	CaO	Common Window Glass.
	Na_2SO_4	Al_2O_3, Fe_2O_3	Very common Bottle Glass.

The ingredients are heated together into a fused mass ; and this has to be maintained for a number of hours at a temperature of from 1,000° C.–1,200° C. in order to refine it. The refining has to be done carefully, as if the glass is kept near its fusing-point for too long a time, a phenomenon known as de-vitrification occurs, spoiling the glass. It is therefore necessary that when



the glass is ready, and has been allowed to cool to a pasty condition, it should be worked quickly to avoid spoiling.

A description of the generating plant is then given. It is a water-driven three-phase alternating current plant in units of 500 h.p. A stand-by steam-driven set, for use when water is scarce, is in course of erection. The object of the installation is to distribute current to the surrounding villages and factories, up to a distance of 18 kilometres, and for this purpose the current is transformed from 540 volts up to 10,000.

Then follows a description of the glass-making electric furnaces, beginning with the first attempt, and then showing the successive improvements.

Throughout the whole range the principle has remained the same, viz., a series of three steps made of refractory material, on each of which a powerful arc is at work. The glass-making mixture is fed from a hopper on to the top step, and passes successively through the arc on each step, finally falling in molten drops into a basin, where it is kept fused by coke or gas for refining.

Working holes admit of the glass being drawn from this after refining for working, or else a further vessel is attached for the purpose.

The accompanying sections show the most recent form of furnace employed. The results obtained up to the present show that the system is very wasteful of heat as compared with modern gas-fired glass furnaces

These can be worked with from 1·5 to 2·8 kg. of coal per kg. of glass made, while the figures obtained show that a current equivalent to 9·3 kg. of coal was used per kg. of glass made electrically. The inventors believe that they will finally succeed in reducing this to an equivalent of from 1·0 to 1·5 kg.

The author analyses the results obtained, and suggests improvements. He describes a further improved furnace now about to be started. There are a few words of discussion on the paper. J. L. F. V.

REFERENCES.

185. *Requirements of Electricity in Manufacturing Works.* **W. S. Aldrich.** (Elect. Rev. 49. pp. 614–615, Oct. 11, and pp. 650–652, Oct. 18, 1901. Paper read before the Amer. Soc. Mech. Eng. (Milwaukee meeting, May, 1901.)—The paper contains a detailed description of the subject under the following heads :—1. General considerations. 2. Economics of electricity in manufacturing. 3. Influence of electric transmission upon factory buildings. 4. Influence of electric transmission upon workshop expansion. 5. Influence of electric drive upon arrangement of machinery. 6. Changing from the old to the new system of driving. 7. Application of the electric drive. 8. Selection of equipment. 9. Losses in factory transmission. 10. Efficiency of electric transmission. 11. Operation and testing of factory installations.

186. *Standardisation of Incandescent Lamp Sockets.* (Elektrotechn. Zeitschr. 22. pp. 647–650, Aug. 15, 1901.)—The Reichsanstalt has undertaken to test sockets &c., with a view to ascertaining whether they conform to the regulations laid down by the Verband Deutscher Elektrotechniker. The article contains a statement as to the limits of allowable error, and a discussion of the reasons for the determination of the said limits.

GENERATORS, MOTORS, AND TRANSFORMERS.

187. *Determination of Efficiency of Dynamos.* **G. Bienaimé.** (In Élect. 10. pp. 517-519, Nov. 25, 1901. Paper read before the Soc. Industriel du Nord de la France, Oct., 1901.)—The C^2R losses are easily calculated, b the other losses must be found by experiment. To do this the dynan should be run light as a motor, at the same speed and the same volts as gives in the armature when running as a generator at full load. But if it impossible to get sufficient voltage to do this, the losses may be found b running it properly excited at two different lower speeds. Since the curre required to run it is a linear function of the volts, the current which woul be required to run it at the full volts can then be calculated. This is base on Housman's method of separating the losses due to Foucault currents fro the losses due to hysteresis and friction. R. B. F

188. *Theory of Commutation.* **K. Pichelmayer.** (Elektrotechn. Zeitsch 22. pp. 967–969, Nov. 21, 1901.)—Referring to the papers of Girault, Fische Hinnen, and Arnold, the author shows that the necessary condition for spark less running as established by these authors may be thrown into a slightl different form, which expresses the fact that the mean e.m.f. of self-induc tance during the period of the short-circuit must be less than the drop c potential due to the brush contact resistance. This condition is, strictl speaking, applicable only to the case in which the width of the brus approximately equals that of a segment. It may, however, be extended t the case in which several coils are simultaneously short-circuited, the onl necessary modification being that to the e.m.f. of self-inductance we have t add the e.m.f. of mutual inductance. This latter is assumed by Parshall an Hobart to be, for two neighbouring conductors, equal to the self-inductanc e.m.f. of one conductor. The author's measurements show that the e.m.f. c mutual inductance for two neighbouring coils is only from 30 to 60 per cen of the self-inductance e.m.f. A. F

189. *Eddy Currents in the Pole-pieces of Direct-Current Dynamos.* **R. V Picou.** (Ind. Élect. 10. pp. 493–495, Nov. 10, 1901.)—The principal losse due to eddy currents in direct-current dynamos occur in the bolts for holdin together the core disks, and also in the polar faces when the armature ha open slots. The losses due to this latter cause are discussed in this pape Periodic variations of high frequency in the magnetic flux at the polar face are caused by the teeth of the armature, and calculations are made to try an find the magnitude of this effect. The eddy currents in that part of th polar face opposite a tooth of the armature tend to demagnetise the fiel whilst the eddy currents opposite a slot tend to magnetise it. The resultan demagnetising action is proportional to the difference between these tw effects. The author discusses what is the probable phase-difference betwee the eddy currents and the e.m.f.'s giving rise to them. Seeing that the pol pieces are massive, this phase-difference is probably very large, although th effect of the high frequency is to confine the eddy currents to a thin layer o the surface of the iron. He calculates the eddy current losses on the pol pieces of a four-pole 70-kw. machine making 600 revs. per min., and havin

55 slots on a drum armature whose diameter is 50 cm. The maximum flux is 316,000 maxwells and the minimum 224,000 maxwells, the air-gap being 2 mm. He shows that the demagnetising action of these currents can be neglected, and by making certain assumptions he calculates that the power dissipated by them is 191 watts. If the polar faces had been covered by a sheet of copper 1 millimetre thick, the eddy currents which would be localised in it would give exactly the same loss. The author thinks that the loss due to eddies would probably be greater than 191 watts, and points out that if it were much greater then it would be advantageous to cover the polar faces with thin sheets of copper. It is ordinarily assumed that the eddy current loss is proportional to the square of the angular velocity. This is only true when the eddy currents are in phase with the e.m.f.'s producing them. If the phase-difference is large the losses are almost directly proportional to the velocity. Hence methods of separation of the losses due to eddies and hysteresis, based on measurements at different speeds, are inaccurate. A. R.

190. *Sparkless Collection.* **C. W. Hill.** (Elect. Rev. 49. pp. 462–463, Sept. 20, 1901.)—The author comments on H. A. Mavor's paper (*l.c.* pp. 489–490). Mr. Mavor says the ampere-turns on the armature producing cross-turn reaction should not exceed 25,400 per inch length of the space; then if the ratio of e, the average e.m.f. per section of armature to r, the reaction voltage of a section undergoing commutation is not less than 2, the machine will be sparkless. The author gives a different expression $\frac{A - A_1}{A_2}$ where A = total ampere-turns in gap, A_1 = armature reaction expressed in ampere-turns, A_2 = magnetising ampere-turns in that portion of the armature which is undergoing commutation, and says that $\frac{A - A_1}{A_2}$ should be of such a value that $\frac{e}{r}$ would be equal to 2. This, however, is not sufficient to prevent sparking. He gives an example where $\frac{e}{r} = 4{\cdot}3$, and yet there was slight sparking. Other magnetic conditions, such as the number and density of teeth, &c., must receive careful consideration. R. B. R.

191. *Air-gap Induction.* **F. W. Carter.** (Elect. World and Engineer, 38. pp. 884–888, Nov. 30, 1901.)—The author begins with a brief *résumé* of a previous paper [see Abstract No. 2101 (1900)]; he then solves an ideal problem, so devised as to resemble very nearly that of the magnetic flux between a smooth pole-face and a slotted armature. His solution shows that few lines of force penetrate far into the slot, so that, unless it is very shallow, which is not the usual case, the depth has little effect. Formulæ and diagrams are given by which the effect of the slot can be calculated. He also shows how to allow for the effect of an internal ventilating duct. The following formula enables the eddy loss in the pole-faces to be calculated when the amplitude of the variation of the flux is known :—

$$P = 8B^2D^2n^{\frac{3}{2}}\mu^{-\frac{1}{2}}s^{-\frac{1}{2}}10^{-13},$$

where P is the loss per square inch of pole-face in watts, B is the amplitude of the variation in lines per square inch, D is the diameter of the armature in inches, n the speed in r.p.m., s the number of slots in the armature, and μ the permeability of the iron of the pole-face for the induction at which it is being

worked. Formulæ are given to determine B approximately. He suggests a method of mapping out the magnetic field in an air-gap by finding, in the ordinary laboratory manner, the lines of flow on a plate cut in a particular shape through which current is flowing. The solution of an ideal case by the method of conjugate functions is given, and illustrates how complicated the exact solution of the problem is. A. R.

192. *The Inductor Alternator.* **E. Heitmann.** (Elect. World and Engineer, 38. pp. 548–549, Oct. 5; 594–596, Oct. 12; and pp. 636–638, Oct. 19, 1901.)—The electrical and magnetic features of the inductor alternator are considered in detail. It is pointed out that the direction of magnetisation is never completely reversed, as it is in other types of alternators, but merely increases from zero to a maximum value, and again decreases to zero with a nearly constant direction. Upon this fact depends, to a large extent, the economical design and good operation of inductor alternators. Owing to the incompleteness of the cycle, very high-line densities can be employed without bringing the iron losses up to those found in other types. Working the teeth at such high-line densities, viz., on the top of the saturation curve, gives improved regulation. The leakage around the slot is inversely proportional to the reluctance of the path, and the fact that the teeth are worked at high-line densities in inductor alternators therefore makes the reluctance of this path very great. The winding is of the style generally known as a concentrated winding, usually one slot per pole per phase, and an approximation to a sine curve is obtained by shaping away the pole surface so as to vary the air-gap density. Details of design curves and other data are given of various inductor alternators associated with the names of Stanley, Kelly and Chesney.

For a 500 kw., 2,500 volts, 60 ∿, machine, at a speed of 100 r.p.m., the following figures are given :—

Power-factor.	Regulation.	Field Current.
100 per cent.	5·6 per cent.	85 amperes
90 „	10·5 „	100 „
80 „	11·6 „	105 „
70 „	13·0 „	110 „

The no-load field current is 79 amperes, and the increase in field current from no-load to full load at 70 per cent. power-factor is about 40 per cent.

The efficiencies are :—

Per Cent. Load.	Per Cent. Efficiency.
125	94·0
100	93·8
75	92·7
50	91·0
25	86·0

A turbine-driven machine 2,000 kw. 2,200 volts 60 ∿ 240 revs. gave the following figures :—

Power-factor.	Regulation.	Field Current.
100	3·0	154
90	8·2	174
80	11·0	180
70	11·4	187

The no-load field current is 146 amperes at 2,500 volts, and thus the increase

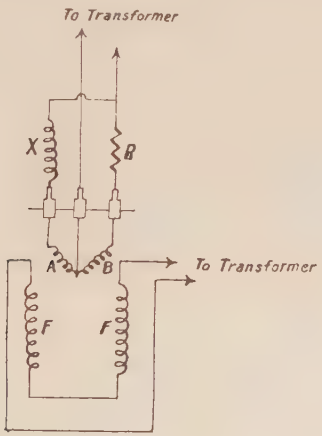
in field current from no-load to full load on a 70 per cent. power-factor is about 30 per cent. The efficiencies are :—

Per Cent. Load.	Per Cent. Efficiency.
125	95·0
100	94·7
75	93·5
50	92·0
25	89·0

E. K. S.

193. *A New Synchroniser.* **F. P. Woodbury.** (Amer. Electn. 13. pp. 527–528, Nov., 1901.)—An instrument devised by P. M. Lincoln to indicate not only when two machines are in synchronism, but to show which machine is running the faster. In shape and size the instrument resembles a two-pole fan motor, but with a dial and pointer in place of the fan and guard. The field magnet is laminated, and the rotor is an ordinary armature core with two coils wound, practically, at right angles to each other, and connected as shown in the diagram.

A and B are armature coils ; F,F the two magnet limbs, R a non-induc-



DIAGRAMS of CONNECTIONS

tive resistance in the form of an incandescent lamp ; X an inductance coil. The latter can be adjusted by altering the air-gaps so as to produce a difference of phase of 90° between the currents in the two coils A and B. The self-induction in the stator coils FF produces a lag of about 90°. When the current in coil A is in phase with the current in the stator winding FF, that in coil B is 90° out of phase with it. Coil A, therefore, sets itself at right angles to the field, and the pointer stands vertically and indicates synchronism. When the current in coil B is in phase with the stator current, B will lie at right angles to the field, throwing the pointer into the horizontal position, either to the right or left, according to which machine is leading.

When the machines are in direct opposition the pointer stands vertically, but points downwards. Intermediate phase conditions produce intermediate positions of the pointer. The foregoing assumes both machines to be running at the same speed. A difference between the speeds of the two machines causes the pointer to rotate backwards or forwards, according to whether the machine being synchronised is running slower or faster than the other. F. B.

194. *Parallel Running of Alternators.* **H. S. Meyer.** (Elektrotechn. Zeitschr. 22. pp. 905–908, Oct. 31, 1901.)—The author sums up the reasons which have led to the practical importance of this problem as follows :—(1) The fact that for the generation and distribution over extended areas of large amounts of power, polyphase currents are preferable to continuous ones ; (2) the tendency towards the adoption of the largest possible generating units ; (3) the almost universally established practice of coupling the generators direct to the prime movers ; (4) the combination of continuous-current distribution with alternating-current generation, by the use of rotary converters. The problem of parallel running is next discussed in detail. Irregularities in the angular velocity of the generators are considered under two heads :—(1) Those due to the hunting of the prime-mover governors—this evil may be remedied by the use of properly designed oil dash-pots ; (2) those arising from the periodic fluctuations in the driving torque during each complete revolution of the engine. In connection with these latter the author gives the complete theory of flywheel design. The paper concludes with a description of an ingenious electrical method, devised by the engineers of the General Electric Company, for determining the speed fluctuations. A small continuous-current dynamo or motor (about 0·5 kw.) has a bicycle wheel mounted on its spindle, the tyre of the wheel pressing against the flywheel of the generator. The field of this small machine is independently excited, and the excitation is varied until the e.m.f. equals that of a battery of secondary cells. The latter is then connected to the brushes of the dynamo through a low-reading voltmeter, the e.m.f.'s being in opposition (if each e.m.f. is about 100, the voltmeter would be arranged to give a maximum reading of, say, two volts). If the generator speed were absolutely constant, no reading would be obtained on the voltmeter ; on account of speed fluctuations, however, the voltmeter is kept vibrating to and fro, and from the amplitude of its readings the percentage speed fluctuation is easily obtained. **A. H.**

195. *Armature Reaction in Polyphase Generators.* **K. Pichelmayer.** (Elektrotechn. Zeitschr. 22. pp. 908–909, Oct. 31, 1901.)—This paper is mainly concerned with the value to be assigned to the back-turns of the armature when dealing with a highly inductive load. The author recommends the use of a formula given by Kapp for a sine distribution of flux, and for the typical flat-topped wave of flux gives a table of values of the corresponding constant for various types of winding. The amount of inductive drop in an armature may be roughly ascertained experimentally by removing the field-magnet flywheel and measuring the p.d. required to maintain the full-load current through the armature. **A. H.**

196. *Boucherot's Three-phase Induction Motors.* **H. Luraschi.** (Elettricità, Milan, 20. pp. 598–601, Sept. 21 ; and pp. 611–614, Sept. 28, 1901.)—The author describes the induction motors made by the Société Anonyme des Applications de l'Électricité under Boucherot's patents. The novel feature in the motors is the insertion of resistance in the rotor without the use of brushes. The rotor has the ordinary squirrel-cage winding, with a ring short-circuiting the bars at each end. In the middle, however, the bars are again connected together, but by strips of resistance material. The stator is composed of two separate and similar parts, each a complete stator acting on one half of the rotor, and arranged to turn one relatively to the other, round the axis of the motor. When the two portions are in their normal position, with poles of like sign adjacent, the rotor currents flow round the squirrel-

cage without passing through the resistance ring. If, however, the stators be displaced, they induce currents in any one rotor bar which are in opposition, more or less according to the amount of displacement; the resistance ring then forms part of the rotor circuit, and its effect is greater the greater the displacement of the stators. The motor then is started with the stators displaced so as to have poles of opposite signs adjacent, when the whole rotor current must pass through the resistance ring; the stators are gradually moved back to their normal position, which has the effect of cutting out the rotor resistance, by making the current take other paths. In large motors this displacement of the stators becomes mechanically difficult, and the inventor then puts two windings on a single solid stator, and displaces the phase of the current in the two windings by a phase-transformer. G. H. B.

197. *Automatic Starter for Asynchronous Polyphase Motors.* (Ind. Élect. 10. pp. 457–458, Oct. 10, 1901.)—A cylindrical box, made of some insulating material, and divided, for a three-phase motor, into three compartments, by insulating partitions of which the planes are parallel to the ends of the box, is mounted coaxially on the spindle of the motor. In each compartment are fixed two metal studs, which pass through the wall of the box at opposite ends of a diameter, the three studs at one side being connected together outside the box by a metal strap, while the other three are connected to the points of junction of the star-wound rotor windings and the starting resistances. In each compartment is a quantity of mercury, the amount of which is adjusted so that, with the motor at rest in any position, one at least of the contacts must be clear of the mercury. When the motor is started and has attained a certain speed, the mercury, under the influence of centrifugal force, spreads out into an annular sheet, and short-circuits the starting resistances. B. P. S.

198. *Rating of Traction Motors.* **M. Müller.** (Elektrotechn. Zeitschr. 22. pp. 921–924, Nov. 7, 1901.)—As an approximation, the author neglects the hysteresis and eddy-current losses occurring in a motor, and assumes that the total loss varies as the square of the current. Assuming further that the rate at which heat is lost by radiation varies as the temperature rise, and equating the difference between the rate of gaining and losing heat to the rate at which heat is accumulating in the coils (= thermal capacity × rate of temperature rise), the author obtains a differential equation whose solution is—

$$\tau = \frac{i^2}{b}\left(1 - e^{\frac{t}{a}}\right) + \tau_0 e^{-\frac{t}{a}}$$

where τ = temperature at time t; τ_0 = initial temperature; i = current, and a and b are constants. In order to determine a and b experimentally, we note the values of τ after any convenient interval from the time of starting, and again when τ has become steady ($t = \infty$); the latter reading gives $b = i^2/b$, and the former enables us then to calculate a. The author uses this formula to study the heating of a motor under given conditions of service; and shows that with a variable current the mean square value of the current, when substituted in the above equation, gives results sufficiently near the truth. He draws special attention to the extreme slowness with which the motor cools down after having been used, the law of cooling being $\tau = \tau_0 e^{-\frac{t}{a}}$. A. H.

199. *High-speed Railway Motors with Phase Compensation.* **A. Heyland.** (Elektrotechn. Zeitschr. 22. pp. 924–925, Nov. 7, 1901.)—With reference to a recently described induction motor for a high-speed railway, the author points out the advantages which would result from the adoption of his method of making the power-factor equal to unity [see Abstract No. 2475 (1901)]. The no-load current would be reduced from 50 to 3 amperes, no change of connections would be required when starting under an overload of three times the normal load, the power-factor would be much higher under all conditions of working, and a powerful braking effect could be obtained by a single change of connections, and without the use of a battery of secondary cells such as was required in the case of the motor referred to.

A. H.

200. *Transformers.* **A. S. M'Allister.** (Amer. Electn. 13. pp. 471–474, Oct., 1901.)—In this paper the author discusses the elementary theory of the alternate-current transformer, explaining the various reactions and phase-relations both in the ideal transformer and under normal working conditions. The distortion of the magnetising current is due to the increase of reluctance of the magnetic circuit through saturation, which demands at maximum magnetisation a larger current than would have been required for a reluctance of the core equal to that at low magnetic density, thus causing the exciting current wave to be peaked. Hysteresis causes the current wave to reach its zero value sooner than otherwise. With regard to regulation, just as a lagging secondary current drawn through a reactance causes a drop at the receiving end, so a leading current of equal value through the same reactance may cause an actual increase in the apparent receiver voltage. B. P. S.

201. *Leakage Drop in Transformers.* **O. S. Bragstad.** (Elektrotechn. Zeitschr. 22. pp. 821–824, Oct. 3, 1901.)—The total drop in a loaded transformer may be regarded as made up of the resistance drop and the reactance drop, the former being in phase, and the latter in quadrature, with the current. After giving an elegant graphical construction for predetermining the drop when the primary p.d. is constant, or the primary p.d. when the secondary p.d. is constant, the author discusses the experimental determination of the equivalent resistance and inductance of a loaded transformer. One such method is the well-known one due to Kapp, in which the secondary is short-circuited. The author has devised the following highly ingenious method, which he calls the "method of opposition," and which may be applied to a transformer which is at work, provided another precisely similar transformer is available. An ammeter and the current coil of a suitable wattmeter are included in the secondary circuit of the loaded transformer. The primary of the unloaded auxiliary transformer is joined across the primary mains, in parallel with that of the first transformer, one end of whose secondary is connected to one end of the secondary of the auxiliary transformer, the connection being made so that the secondary e.m.f.'s are in opposition. A voltmeter is next connected to the free ends of the secondaries. This will give the total impedance drop in the loaded transformer. Lastly, by joining the free ends of the secondaries across the pressure coil of the wattmeter, the total power lost by heating of the coils is found, and from this the resistance drop component is immediately obtained. Some numerical results are given to show how consistent are the values which may be obtained by means of this method.

A. H

202. *Stable Running of Rotary Converters.* **M. Leblanc.** (Comptes Rendus, 133. pp. 679–681, Oct. 28, 1901.)—Two cases are described in which the armature of a rotary converter, at certain loads, becomes dynamically unstable, and, instead of maintaining a constant speed, takes up a pendulum movement, the speed accelerating and retarding in turn between limits depending on the load. (1) In the first case the converter was arranged to transform from direct current (supplied from a secondary battery, from which also the fields were excited) to three-phase alternating, which was transformed first up and then down, and finally absorbed by a rheostat. As the load was gradually increased, the oscillations began, becoming finally very considerable. The explanation given is the demagnetising effect of the three-phase wattless currents, which, beyond a certain limiting load, are increased by any accidental increase of speed. This is explained by the form of the expression which represents the current I as a function of the speed ω and of the load ; $dI/d\omega$ begins by being negative, but at a certain "limiting load" passes through zero and changes sign. The increase of current in the armature weakens the field and causes the machine to run still faster. The "limiting load" should therefore be greater than the maximum load which the machine is intended to give. Lowering the frequency of the generated alternating currents, and diminishing the coefficients of induction and magnetic leakage of the transformers, increases the limiting load. (2) In the other case, a rotary converter was connected to alternating mains, and worked perfectly up to full load. When, however, an alternating booster, with large magnetic leakage, was put in the primary circuit in order to regulate the pressure of the direct current generated, as soon as half load was reached the oscillations of the armature began. This is explained as follows : With a constant field, excited by secondary batteries, and an alternating terminal p.d., of constant r.m.s. value, an increase of speed is accompanied by a diminution of torque. But an increase of p.d. involves an increase of torque. At small loads the first effect predominates ; but as the load increases a point is reached where increase of speed is accompanied by increase of torque, and the machine accelerates until the torque ceases to increase. Being then in unstable dynamic equilibrium, it begins to slow down. A remedy is to wind the inductor circuit with two windings, one a magnetising coil in shunt across the brushes supplying the direct current, the other, a demagnetising coil, in series with the generated current. The machine then works as well with a booster in the alternating circuit as if connected direct to the mains. B. P. S.

203. *Motor-Generators* v. *Rotary Converters.* (Electrician, 47. pp. 985–987, Oct. 18, 1901.)—This article is substantially a communication from the Oerlikon Company, who have lately tested motor-generators, both of the synchronous and asynchronous types. An elaborate series of curves is given, showing the characteristics of the various machines, and a comparison is made between rotary converters and motor-generators, from which it would appear that the efficiency of motor-generators is not less, but, if anything, rather greater than that of rotary converters. The synchronous motor-generator was for 50-cycle current at 3,500 volts, and was coupled direct to an 8-pole continuous current dynamo for an output of 1,350 amperes at 260 volts at 375 r.p.m. The induction motor was for 6,000 volts and 50 cycles, and was coupled direct to a 4-pole dynamo giving 510 amperes at 450 volts at 370 r.p.m. The performances of these machines are contrasted with those

of rotary converters of another make, having somewhat similar outputs. Th results are summarised in the following table :—

	Oerlikon Co.'s synchronous motor-generator of 350-kw. capacity.			Oerlikon Co.'s asynchronous motor-generator of 230-kw. capacity.			Static transformer and rotary converter of 250-kw. capacity.			Static transformer and rotary converter of 500-kw. capacity.		
	Motor.	Generator.	Total.	Motor.	Generator.	Total.	Transformer.	Converter.	Total.	Transformer.	Converter.	Total.
Weight in Tons. ...	12	11	23	8	9·5	17·5	4·65	8	12·65	6·9	14·5	21·4
Efficiency—full load	96	95	91	94·5	95	90	96·6	92·7	89·5	97	93·2	90·5
Efficiency—¾ load	93	92·5	87	93	92·6	86	95·2	89·2	85	95·8	89·5	85·5
Efficiency—½ load	88	90	80	89	88	78	—	—	—	—	—	—

The article points out that if the decision depends on the merits of simplicity of starting manipulation, upon the safety of service in case of interruption to the line, and the absence of tendency to hunting on the part of the generators, the induction-motor system is by far the most advantageous, and this system would seem, in general, to be preferred by the Oerlikon firm. The pros and cons of the various systems are concisely discussed.

H. S. Meyer criticises the figures and statements made in the above article. (See Electrician, Nov. 1, 1901.) He points out that the question of cost is altogether disregarded, and that, from this point of view, the rotary converter combination is far the best. He also considers that the Oerlikon Company has rather understated the efficiency of rotary converters. W. H. S.

REFERENCES.

204. *Compound Alternators on the Hutin and Leblanc System.* **J. Routin.** (International Electrical Congress at Paris, Reports, pp. 137–154, 1901.)—This paper is on similar lines to the one dealt with in Abstract No. 2100, 1900. G. W. DE T.

205. *Alternating Currents obtained from Continuous-Current Armatures.* **F. Eichberg.** (Elektrotechn. Zeitschr. 22. pp. 563–564, July 11, 1901. Paper read before the Verband Deutsch. Elektrotechn. at Dresden, 1901.)—The author considers a number of arrangements in which certain points in the winding are connected to an auto-transformer, by means of which three-phase alternating p.d.'s may be obtained, the amplitudes of which exceed the value of the continuous e.m.f. A. H.

206. *The Regulation of Alternating-Current Generators.* **A. S. M'Allister.** (Amer. Electn. 13. pp. 392-394, Aug., 1901.)—The regulation of an alternating-current generator is defined as the percentage increase in terminal e.m.f. when the full-load current of specified power-factor is thrown off, the speed and excitation remaining the same. A clear discussion, with instructive diagrams, is given of how the regulation depends on the number of phases and the character of the load on each phase. A. R.

207. *The Graphical Theory of Synchronous Motors.* **P. M. Verhoeckx** and **A. Blondel.** (Écl. Électr. 29. pp. 131–133, Oct. 26, 1901.)—Letters from Verhoeckx and Blondel discussing the relative merits of their graphical constructions for determining the "Wattless" current of a synchronous motor when the "watt" current is constant. [See further Abstracts Nos. 2476 and 2010 (1901).] A. R

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

208. *Erection of Overhead Power Lines.* **Loppé.** (Soc. Int. Élect., Bull. 1. pp. 455-484, Aug., Sept., Oct., 1901.)—The author considers, in the first place, the effect of variations of temperature in causing both elongation and change of elasticity, giving formulæ and tables for determining—(1) the length of the wires in times of the sag and the span ; (2) the change of sag of copper wires, firstly, in times of the temperature change, of the initial sag, and of the initial tension ; and, secondly, in times of the change of pressure per metre run, of the initial sag, and of the initial tension. The effect on the impedance of the line, of the distances between the wires, is then discussed, and tables are given, due to Blondel, which were originally published in 1894 in "l'Éclairage électrique ;" after which the author proceeds to consider the principles determining the best length of span under given circumstances, and tables are given to facilitate the evaluation of the formulæ for wires of copper and aluminium, allowing for a wind pressure of 125 kg. per square metre of superficial area of the wires. This pressure will be about 0·60 of that on a plane surface.

Increase of span involves, *cæteris paribus*, a corresponding increase of sag, which is limited by the greatest admissible height of the poles, and, on account of the necessity of preventing contact, by the distance between the wires. In American practice the sag is not allowed to exceed double the latter distance, but the author states that no trouble has arisen from this cause in the case of the Paris and Bordeaux telephone line, consisting of a pair of wires 4·5 mm. in diameter, separated by an interval of 0·65 metre, and having spans of from 70 to 80 metres, and therefore a sag exceeding 2 metres. The author, as an example, gives in detail the calculations for a three-wire three-phase line of copper-wire 5 mm. in diameter, with a maximum allowable tension of 8 kg. per sq. mm., and under given conditions as to maximum wind pressure, temperature limits, and possible accumulation of snow or ice. The necessity is insisted on of diminishing the tension at which the wires are erected, when, owing to crossing other lines, or for any other reason, the span has to be decreased, and advises its decrease in the same ratio as that of the span. In conclusion, the author discusses, by the aid of tables of the mechanical and electrical constants of copper, aluminium, and various kinds of bronze, the relative advantages of these materials for overhead line wires. With copper costing, as at present, 2 fr. 20 per kg., and aluminium 4 fr. per kg., it is shown that both the best length of span and the cost will be about the same, whichever material be employed. With regard to dissipation of heat, aluminum is at a disadvantage compared with copper, but the use of bronze is strongly advocated in preference to either, even for wires of large diameter.

G. W. DE T.

209. *Composite Metal Span-Wire Poles.* (Street Rly. Rev. 11. pp. 795-796, Oct., 1901.)—The average life of wooden poles is about eleven years, and of metal poles about thirty-three years. A number of wooden poles would cost for thirty-three years about $3,500, while pipe-poles in the same period would

cost only $2,500. A system of composite iron poles has been devised by J. Lanz, of Pittsburgh, which includes tubular-poles built up of plates and channel iron. A description of these, with illustrations, is given in the article. Plain I beams are advocated in some cases, and it is pointed out that a 9-inch I beam pole of 21 lbs. per foot weight, loaded in the direction of the web, is equal in strength to an 8-inch pipe, the weights being respectively 630 and 1,220 lbs. for 30-feet lengths. E. K. S.

210. *Poles of Armoured Cement.* **E. Barni.** (Elettricità, Milan, 20, pp. 647–648, Oct. 12, 1901.)—The paper describes poles constructed by the author, consisting of two H girders, fixed together by bolts and distance pieces to present a section ⌶, the distance between them being, at the top, 14 cm., and at the bottom 50 cm. A short length of wood is fixed between the girders at the top, and projects above them, to carry the insulators. The space between the girders is then filled with rubble cement. The author's experience with these poles has been satisfactory; their cost, for a height of ten metres above the ground, is 120 francs. G. H. B.

211. *Heating of Electric Conductors.* **W. Weiler.** (Elekt. Runds. 19, pp. 42–43, Nov. 15, 1901.)—The author considers the question of determining the temperature finally reached by a bare conductor carrying a given current, and arrives at the formulæ—

$$i = \frac{\pi d}{2}\sqrt{\frac{kd + 0{\cdot}000557t}{\rho(1+\alpha t)}}$$

and—

$$k = 0{\cdot}05625(1{\cdot}0077)^{\theta}(1{\cdot}0077^{t} - 1),$$

where i = current, d = diameter of wire in centimetres t = excess of final temperature over that of the atmosphere, θ = temperature of the atmosphere, ρ = specific resistance of the metal, α = temperature coefficient, and k = watts dissipated per sq. cm. of exposed surface of the wire. A diagram is given from which it is possible to ascertain the rise of temperature in copper wires of from 0·1 to 12 mm. in diameter, and carrying currents which range up to 400 amperes. W. H. S.

212. *Wiring Rules.* **C. H. Wordingham.** (Electrician, 48. pp. 84–85, Nov. 8, 1901.)—While it is impossible to draw up a set of rules to cover every case, there are certain conditions common to all cases which should be rigorously fulfilled. These may be codified, when necessary, and supplemented in each case by a detailed specification. The rules should be devised to guide competent workmen, not to teach incompetent men. Fittings should be tested by an independent central authority, and those types which are found satisfactory should be officially registered.

Supply rules are totally distinct from wiring rules, and should contain, in addition to the general conditions of supply, regulations for the prevention of disturbance of other consumers by leakage and sudden changes of load, and the prevention of shock. All such rules should be confined to matters essential to the provision of a satisfactory supply to all classes of consumer. A. H. A.

213. *Wiring Rules.* **Budde.** (Elektrotechn. Zeitschr. 22. pp. 972–977, Nov. 21, 1901. Paper read before the Verband Deutscher Elektrotech-

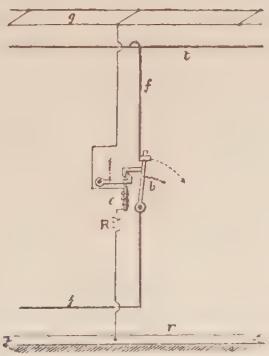
niker.)—The wiring rules adopted by the Verband Deutscher Elektrotechniker are here given in so far as they apply to low tension installations. These are defined to be those in which the voltage between two cables insulated from earth does not exceed 500, or in which the voltage between an insulated and earthed cable does not exceed 250. An appendix contains the standards laid down for the various sizes of cables and their insulation.

W. H. S.

214. *Duplicate Feeders.* **L. Andrews.** (Elect. Engin. 28. pp. 632–633, Nov. 1, 1901.)—The author refers to a paper in which he described a system of duplicate feeders with discriminating cut-outs [see Abstract No. 1289 (1898)], and describes a case at Hastings in which a feeder broke down, but by the operation of the cut-out, the faulty feeder was disconnected, and the supply maintained without interruption through the duplicate feeder.

A. H. A.

215. *Trolley Wire Protection in Santiago de Chile.* (Elect. Rev. 49. pp. 502–503, Sept. 27, 1901.)—As there had been several accidents by telephone wires coming in contact with trolley wires the Santiago Municipality appointed a committee to report on the various protective devices. The committee decided that the only effective system was to earth the guard wire to the rail, but the traction company objected that its poles would not carry the extra weight of the



heavy guard wires, and also that the whole system would be subjected to a severe shock in case of accident. Salazar therefore devised the arrangement shown in the sketch, which has the following advantages: 1. Certainty of traction with a predetermined current. 2. The low conductivity and small sectional area required in the guard wire. 3. Independence between the circuit breaker and main feeder. 4. The fact that the arrangement does not operate by excess of current, so that neither fuses nor cables are affected by an accident. 5. The absence of fuses to be replaced, enabling the circuit to be remade by merely restoring the breaking lever to its normal position.

E. K. S.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

216. *San Paulo (Brazil) Electricity Works.* (Street Rly. Journ. 18. pp. 167–174, Sept., 1901.)—The station is driven by water-power, being situated at Parnahyba, 21 miles from San Paulo. It contains three 1,000-kw. three-

phase alternators, direct-coupled to turbines running at 200 r.p.m. Th power is generated at a pressure of 2,300 volts, and is then transformed t a pressure of 24,000 volts for transmission to San Paulo. Current is di tributed both for lighting and traction, the tramway generators being drive by induction motors, and the lighting carried out by alternate current.

W. H. S

217. *Central Power Station of Birmingham, Ala., U.S.A.* **J. R. Williams** (Amer. Electn. 13. pp. 421–424, Sept., 1901.)—System : Three-wire direc current at 125 volts, and series arcs for lighting ; direct current at 500 volt for traction ; single-phase and monocyclic alternating current for supplyin the remoter districts. The boiler-rooms contain 24 horizontal return-tub boilers, working at 120 lbs. per square inch, and feeding a single wrought iron header 14 inches in diameter. The feed-water is heated by Wainwrigh heaters. The furnaces are fired by hand. The engine-room contains 10 simpl non-condensing Corliss engines and one single-valve automatic engine ; fue is so cheap that compound condensing engines offer no prospects of economy Six of the engines are coupled in pairs ; two of these sets have cylinder 24 in. × 48 in., and drive two 875-kw. railway generators at a speed o 82 r.p.m. ; the third set has cylinders 20 in. × 30 in. and drives two 200-kw lighting generators, working at 125 volts each, at 150 r.p.m. Four othe engines have cylinders 21 in. × 48 in., 18 in. × 42 in., and 26 in. × 48 in respectively, and drive various generators by means of counter-shafting. The automatic engine has a cylinder 20 in. × 20 in., and drives direct two 100-kw 125-volt dynamos at 200 r.p.m. Open arc lamps are used for public lighting, and enclosed arcs for private lighting. For the supply of the neighbouring towns, part of the alternating current is transformed up and transmitted at 5,000 volts ; it is distributed at 1,040 volts. A 5,000-volt three phase alternator is to be installed for the supply of a railway line to Bessemer 12 miles distant ; transformers and rotary converters will be installed in sub stations for this purpose. A. H. A

218. *The Karlsruhe Central Station.* **F. Winawer.** (Elektrotechn Zeitschr. 22. pp. 847–853, Oct. 10, 1901.)—The boilers are by Steinmulle and the three tandem compound single-crank horizontal engines by Kuhn each driving a three-phase alternator giving 400 kw. at 4,000 volts and 50 ∼, with 66 poles and 91 r.p.m. The paper contains a fairly good description of the cable system and transformer substations. It contain eight good illustrations. E. K. S

219. *Longton Electricity Works.* (Elect. Engin. 28. pp. 546–549, Oct. 18 1901.)—A description is given of this station, which contains two 145-kw dynamos, and a battery of cells, giving 40 kw. for 10 hours. W. H. S

220. *Battersea Electricity Works.* (Elect. Engin. 28. pp. 510–516, Oct. 11 1901.)—This continuous-current station contains four Babcock boilers, eac evaporating 11,000 lbs. of water per hour, fitted with chain-grate stokers, th feed-water being heated by an economiser of 256 tubes. The main steam ring has an internal diameter of 11 inches. The plant includes one 400-kw and two 200-kw. machines, and two steam-driven balancers, the dynamo of which have an output of 46 kw. each. The steam is condensed by ejecto condensers. A diagram is given showing the connections on the switchboard and various interlocking and safety devices are illustrated and describe

The battery-room contains 280 cells, having an output of 100 kw. for five hours. Five feeders have been laid, all of which consist of concentric cables, the conductors having a sectional area of 0·5 square inches. A middle-wire connection is also brought back to the station from two points in the distributing network, the cables laid for this purpose having sectional areas of 0·25 and 0·5 square inch respectively. Street lighting is carried out by means of 240 arc lamps, taking 10 amperes each ; they are connected 10 in series across the 460-volt mains. The article contains several drawings showing the arrangements in the station. W. H. S.

221. *Remodelled Plant of the Georgia Electric Light Company.* (Amer. Electn. 13. pp. 465–471, Oct., 1901.)—The old plant of the Georgia Electric Light Company, organised in 1890, has lately been dismantled, and the station and plant brought up to date. A large number of small generating sets has been replaced by the following equipment :—Two General Electric three-phase alternators each of 1,000 kw. capacity, and one of 600 kw., generating at 2,500 volts and 60 periods ; of these the two larger machines are direct driven by two Rice and Sargent cross-compound engines, and the smaller, through a 48-inch belt, by a Greene engine of similar type ; one 600 volt General Electric railway generator, of 700-kw. capacity, direct driven by a McIntosh and Seymour tandem compound engine ; and a Harris-Corliss tandem compound engine, driving through a counter-shaft several railway generators which have been retained from the old equipment. There are eight Babcock and Wilcox boilers rated at 250 h.p. each, and two rated at 325 h.p. each. Coal is delivered direct from the trucks into bins in the boiler-room. Steam-pipes are all in duplicate. The engines run condensing : a central condenser of 5,000 h.p., two triple expansion duplex circulating pumps, and a "dry vacuum" air-pump, all of the Worthington type, are installed. Green economisers are used, and a Webster open heater. There are also a 200-kw. General Electric and a 100-kw. Short railway generator, both driven by belt from a Greene tandem compound engine ; a 50-kw. exciter for the alternators, direct driven by a Straight Line simple engine, and another exciter driven by a 35-kw. induction motor.

The distribution, apart from the railway service, is on two systems, one area being supplied with alternating current direct from the primary three-phase bus-bars, and another with direct current from a substation with rotary converters fed from the same bus-bars. The direct-current generators in the main station, which supply the railway service, are reinforced by a Westinghouse rotary converter of 300-kw. capacity. In the district of alternating supply about 650 enclosed arc lamps are run in series through constant-current transformers in the main station ; these circuits also comprise about 250 series incandescent lamps of 75 c.p. each. The alternating current primary distribution is by lines carried on poles, the pressure being reduced by transformers to 115 volts at suitable intervals. The substation is provided with a battery of 150 chloride accumulators with a one-hour discharge rate of 2,720 amperes at a minimum e.m.f. of 240 volts ; three 400-kw. General Electric two-phase rotary converters ; six 250-kw. three-phase to two-phase General Electric air-blast transformers, and the necessary switchboard equipment. By means of dial switches operated by small direct-current motor, the secondary e.m.f. of the transformers can be varied from 160 to 240 volts, and therefore the direct-current voltage of the converters, which are connected across the outer bus-bars of the three-wire distribution, from 240 to 360 volts. The motors which operate the dial switches

are worked in either direction by double pole reversing switches. Th neutral bus-bar is connected through switches to the middle of the seconda winding of the transformers. The arrangement of the underground dist bution is described, but calls for no special remark. The change over w made from the old plant to its present form without a single shut-down at th station, and without discontinuing any customer's service for more than a hour and a half. The paper is well illustrated with photographic blocks an diagrams of connections. B. P.

222. *Malakoff (Seine) Electricity Works.* **C. Dantin.** (Génie Civil, 3 pp. 361–365, Oct. 5, 1901.)—These works are intended to supply current for tramway system of a total length of about 40 kilometres within and witho Paris. Inside the city the cars are run by means of accumulators, which ar charged through a trolly from aerial cables erected along the parts of th routes which lie outside the walls, the cars being run from the overhea supply while the cells are being charged. The general construction of th station and of the lines has been carried out by the French Thomson Houston Company. There are six Babcock and Wilcox boilers, arrange in pairs, working at 11 kg. per sq. cm., and each capable of evaporatin 2,900 kg. of water per hour, or 3,100 under forced draught. There is also Green's economiser of 400 square metres heating surface ; two Worthingto feed-pumps, each capable of supplying the whole of the boilers, and a electrically worked pump, of the "Thirion" type, of similar capacity. Ther are in present use two direct-coupled steam sets, each of 500-kw. capacity and a third is to be shortly erected. The generators are 8-pole, compound wound machines, of which the full rated load is 910 amperes at 550 volts they were built by the Société des Établissements Postel-Vinay. The present no special features of interest. They are stated to be capable o working for 24 hours continuously on full load with a rise of temperature no exceeding 50° C. for any part of the machine, and, after this, an overload o 50 per cent. for 1 hour with a rise of not more than 60° C. The efficiencie given are :—One-quarter load, 89·7 per cent. ; half-load, 92·8 per cent. ; three quarter load, 93·8 per cent. ; full load, 94 per cent. ; 50 per cent. overloa 93 per cent. The engines are of the "Allis" type, built by the Société française des Constructions mécaniques. They are of the horizonta compound, condensing type, with Reynolds-Corliss valve gear, runnin at a mean speed of 95 r.p.m. The diameters of the cylinders are 508 an 1,016 mm. respectively, the stroke being 1,220 mm. The connecting rod are of exceptional length, being six times the crank radius. Each engin is provided with two Porter governors, one of which regulates the stea admission to each cylinder simultaneously ; the speed of the engine can b varied while running by an adjustment of this governor. The other is safety device to cut off steam if the engine should run away. The flywhee are 6·1 metres external diameter, and weighs 40 tons (French) each. Figur are given of a 6-hours full load test in which the steam consumption can out at 6·26 kg. per indicated horse power hour (French). In addition to th main engines and generators, there is a small vertical high speed set 70 kw. for works, lighting, &c., which can also be used, if necessary, excite the large generators. The switchboard consists of nine marble pane in an angle-iron frame ; two panels for the two large dynamos, one for th small one, one testing panel, four for the feeder circuits and one for the wor service. The equipment of the switchboard is of the usual character and do not call for detailed description. B. P.

223. *Electric Tramway at Malakoff les Halles (Seine).* **C. Dantin.** (Génie Civil, 39. pp. 383–385, Oct. 12, 1901.)—The total length of the line is 7 kilometres, 6 kilometres being within Paris itself and the remainder without the walls. The cars are fitted with accumulators, by which the former portion of the route is worked, while over the remainder of the line the motors are run from an aerial cable, the accumulators being charged, while running, from the same source. The current is supplied to the overhead system from the Malakoff Electricity Works [see preceding Abstract.] The cells employed are of the "Union" type, 210 in series on each car. The capacity is 45 ampere hours; duration of charge, 15 to 20 minutes. So far the cells have given satisfaction; they are still in good condition though they have travelled over 30,000 kilometres, and been discharged more than 3,500 times. The motors are two in number on each car, each of 35 h.p., of the Thomson Houston Co.'s manufacture; the general equipment of the cars is on the ordinary lines, with the addition of a two-way switch to connect the motors either with the trolley or the cells. The cars are heated as well as warmed electrically, and are provided with compressed air brakes in addition to the ordinary hand-brake. B. P. S.

224. *Power Transmission at Crottorf, Saxony.* **R. Apt.** (Elektrotechn. Zeitschr. 22. pp. 984–988, Nov. 28, 1901.)—This station has been built by the Helios Company for the purpose of supplying current in an agricultural district. Some part of the power, to the extent of about 500 h.p., is derived from a waterfall 2·7 m. high. Three turbines, each giving 185 h.p., and running at 54 r.p.m., are connected to a common shaft by toothed wheels, to which also a three-phase generator is directly coupled. The generator can also be driven by steam, if necessary, the connection being made by a form of friction coupling. A second steam set of similar capacity is also provided. Each three-phase generator has an output of 500 kw. at 7,000 volts, running at 125 r.p.m. Steam is furnished by five Cornish boilers, built by Paucksch, each being 10·14 m. long and 2·2 m. in diameter. The power is distributed over a radius of 15 km. in twenty-seven villages. Usually alternate current is supplied, but in some of the larger villages the lighting is carried out on the direct current system. This is worked as follows. A battery of accumulators is installed, and is charged during the daytime by means of a motor-generator. The lighting current is then provided by the cells, which discharge in parallel with the motor-generator. But even in these places power is supplied for motor purposes by three-phase current, the distribution throughout being effected on the usual overhead system. W. H. S.

225. *The Electric Lighting of Rhode Island.* (Elect. Rev. N.Y. 39. pp. 563–570, Nov. 9, 1901; and also 1584, 1900.)—The principal interest lies in the magnitude of the installation, the lighting district comprising an area of over 300 square miles, and the number of systems supplied from one station.

The systems in use are, single-phase, alternating at 50, 104, 2,200, and 10,000 volts; two-wire direct current at 500 volts; three-wire at 235 volts, with battery substations; three-phase, 2,200 volts; series (open and enclosed) arc lighting, and series incandescent lighting, with both alternating and direct current, and the usual parallel systems of lighting. F. B.

226. *Moulineaux Electric Railway Station.* **F. Drouin.** (Génie Civil, 39. pp. 313–318, Sept. 14, 1901.)—The Compagnie des Chemins de fer de l'Ouest has electrically equipped the lines from the Invalides to the Champ-de-Mars,

and to Meudon, and the paper describes the central station at Moulineaux which supplies these lines. The system adopted is transmission at 5,000 volts and 25 ∿ by three-phase current to substations, where transformers supply continuous current at 500 volts to the line.

The boiler-house contains 27 semi-tubular Meunier boilers, three boilers supplying one engine. The pressure is 12 kg., the heating surface of each boiler 235 sq. m., and the grate surface 3·885 sq. m. The boilers are fired by hand, the coal being tipped into the boiler-house from trucks.

The engine-room contains nine horizontal engines. Six, by Dujardin et Cie, are triple-expansion, four cylinder engines, of 1,350 i.h.p. normal and 1,700 i.h.p. maximum ; the cylinder diameters are 0·650, 1·10, and 1·10 metres for high-, intermediate-, and low-pressure respectively, and the stroke is 1·35 metres. The cut-off in the intermediate cylinder is fixed at 35 per cent., and in the low at 50 per cent. ; it is governed only in the high-pressure cylinder. The flywheel weighs 20 tons. The other three engines, by Garnier and Faure-Beaulieu, are Corliss cross-compound, of the same power. The cylinder-diameters are 0·71 and 1·32 m., and the stroke 1·30 m. The cut-off is governed in both cylinders. The condenser-pumps are worked off a prolongation of the piston rods. Water is taken from the Seine by six centrifugal pumps, driven electrically by 50-h.p. motors.

Each engine drives directly a Westinghouse generator of 800 kw. normal and 1,100 kw. capacity, at 80 r.p.m. The efficiency is 94 per cent. at a power factor of 0 9. The generators are excited at 110 volts, and take from 175–195 amperes. The exciting current is supplied by four sets, each consisting of a compound engine driving a Westinghouse compound-wound dynamo giving 125 kw. at 290 r.p.m. Scale drawings are given of the boilers and alternators, and several views of the station. G. H. B.

227. *Birkenhead Electric Tramways.* (Tram. Railway World, 10. pp. 457–462, Sept. 1901.)—System : Continuous-current trolley at 550 volts. The total length of line is 12 miles, of which 7 are double-track ; the smallest curve radius is 40 feet, and the steepest gradient 1 in 13½. The boiler-room contains three Lancashire boilers by Tetlow Bros., working at 160 lbs. pressure ; each has 966 square feet of heating surface and 38 square feet of grate surface. The feed-water is heated by a Green's economiser of 320 tubes, and is fired by McDougall's automatic stokers. The engine-room contains three Willans' engines, each of 860 i.h.p. capacity at 850 r.p.m. ; the cylinder diameters are 14 and 23 inches, and the stroke 6¼ inch. Klein counter-current jet condensers are used, water being taken from a cooling tower and pond. Each engine drives directly a compound-wound six-pole Siemens generator, giving 409 amperes at 550 volts. The generator efficiency is 93·5 per cent., and the combined efficiency of the set 86 per cent. Feeders are five in number, by the Callender Cable Company and the British Insulated Wire Company, and are laid on the solid system. Two return feeders are brought to the station from the rails. The station is equipped with a battery of 241 E.P.S. accumulators (KW type), giving a discharge of 380 amperes for one hour. The track is equipped on the overhead trolley system. Centre and side poles spaced about 40 yards apart carry, by means of bracket arms, two trolley wires of hard drawn copper, 0·4 inch in diameter, insulated by Aetna insulators. The rails are of girder type, weighing 100 lbs. per yard, laid to standard gauge and tied together by bars every 10 feet. The fishplates are 24 inches long with 6 bolts, and the joints are bonded with double Chicago Crown bonds No. 0000. The foundation of the track is a bed of 7 to 1 concrete, 6 inche

deep, and the roads are paved with granite and red gum wood. There are 15 single deck bogie motor cars fitted with four motors, and 44 single truck cars, of which 31 are double decked, fitted with Peckham trucks and two G.E. 52 motors. British Thomson-Houston B3 controllers are used on the single truck cars with hand and electric brakes, and Spencer's slipper brake; the electric equipment of the bogie-cars is by Witting Bros. The bogie-cars have a seating capacity of 55 passengers, the single-truck single-deck cars, 34; and the double deck, 58. The average speed, including stops, is eight miles an hour, and the maximum ten. The charge per mile is about ¾d., and the maximum 2d. The drawings include a map, rail section, views of station, cars and overhead construction. G. H. B.

228. *Alstaettan-Berneck Electric Railway.* **E. Bignami.** (Elect. Rev. N.Y., 39. pp. 309-312, Sept. 14, 1901.)—A general description of a small country railway. It is operated from two stations, one of which is driven by water-power, and the other by steam. The plant consists partly of single-phase alternators, and partly of ordinary tramway generators. The railway is about 7 miles long. W. H. S.

229. *London United Tramways.* (Electrician, 47. pp. 977-981, Oct. 18, and 48. pp. 4-8, Oct. 25, 1901.)—The generating station at Chiswick occupies a ground space of 154 feet by 106 feet, and consists of an engine-room and boiler-house. The internal walls in each case are faced with glazed bricks, and the engine-room floor is laid with mosaic tiles. The equipment consists of ten Babcock and Wilcox boilers, mechanical stokers of the coking type, a coal conveyor capable of handling 40 tons of coal per hour, and a Green's economiser of 360 tubes. The smoke stack, 260 feet high, is chiefly of interest on account of its foundations. Borings were made at several points on the site, and water was met with at depths varying from 8 feet to 10 feet. The soil was found to consist of sand and ballast, with blue clay underlying at about 28 feet below the surface. The site selected for the stack was near the walls of a stone building. It was feared that, were a solid mass of concrete put down here, it might endanger the stability of the walls. The method adopted was as follows: A hollow rectangular structure of pitch-pine was prepared at ground level, tied together in a very strong manner with bolts and stays, and provided with a cast-iron cutting edge. This shoe was filled up with cement concrete, and when this was well set the ground inside was removed, so that with the aid of the pumping operations the whole might gradually subside. A further layer of concrete was then filled in, and these operations were repeated until the blue clay was reached, when the whole of the lower portion was filled up solidly with concrete so as to equally distribute the weight of the superstructure. The engine-room contains two vertical cross-compound Allis engines at 90 r.p.m. Each of these is directly connected with two 250-kw. compound wound direct current generators, one placed on each side of a 36-ton flywheel. Speed variation does not exceed 2½ per cent. from no load to full load. These sets supply the power needed in the vicinity of the power-house. For transmission to substations there will ultimately be three sets giving three-phase currents at 5,000 volts and 25 ∼. The generators are of the revolving field type, and are excited from the 500-volt direct current bus-bars. The switchboard consists of twenty-seven marble panels each 7 ft. 6 in. in length and 2 feet wide. The switches and bus-bars for the H.T. work are supported by joists in a closed chamber beneath the switchboard floor, the switches being of the oil break type and operated by

levers on the switchboard. The engine-room also contains two 75-kw. sets for local lighting, and power needs in the repair shops. There are also two 15-kw. negative boosters. A 250-kw. rotary converter, similar to those in the substations, is also installed here. It is used either for transforming alternate to direct current, so as to assist in supplying current to the trolley lines, or it may work the other way and send 5,000 volts to the substations. It is excited by a series generator driven by an induction motor connected to the three-phase side of the rotary. This provides a compensating field and prevents variations in the speed of the rotary from variations in the load. The plant includes two surface condensers and cooling towers provided with air propellers. Practically the whole of the overhead equipment is carried out on the span-wire system. Forty-two feeders radiate from the generating station. They consist of lead-covered paper insulated cables drawn into wrought-iron cement-lined ducts. The whole of the feeding arrangements are duplicated. There are two substations, each about five miles from the power-house, and containing two 250-kw. rotary converters and seven transformers. They are capable of 100 per cent. overload without surging or falling out of synchronism. Each rotary has directly coupled to its shaft a 15-kw. booster. A small induction motor is used for starting the converter. The transformers are of 100-kw. capacity. The secondary voltage may be either 310, 330, or 350 volts, according to which terminals are used. They are delta connected. W. W. H. G.

230. *Leeds Electric Tramways.* (Tram. Rly. World, 10, pp. 529–538, Oct., 1901.)—The writer states that by the end of 1901, 61 miles of track and 245 cars would be working electrically. The power-house is on the left bank of the Aire, and within 700 yds. of the centre of the tram system. The site affords ample water supply and cheap coal transport. The original boiler-house held nine boilers of the Lancashire type. In the new house six more are being installed of the same size, viz., 30 ft. by 8 ft., and they are fitted with Bennis automatic stokers. An additional Green's economiser of 544 tubes is included. This and the mechanical stokers are driven by a 10 h.p. electric motor. An electrically driven coal elevator and conveyor takes the coal from the boats and delivers it to the hoppers. The rope-driven sets have been removed, and the following schedule gives details of the new equipment :—

No.	Engine Makers.	H.P.	R.P.M.	Cylinders.	Pressure.	Amps.	KW.	Dynamo Makers.	Poles.
3.	Hick, Hargreaves & Co.	1,450	90	{ H.P. 28 / L.P. 54	150 lbs.	1,600	800	Electric Construction Co.	14
2.	John Fowler & Co.	1,300	112	{ H.P. 29 / L.P. 55	"	1,500	750	Greenwood & Batley	12

The switchboard has twenty-five panels, fitted with Weston instruments. There are three accumulator substations. The cells are of the chloride type with the capacity of 110, 160, and 400 amp.-hours respectively. The feeder cables are laid in Doulton's casing and iron pipes. The overhead equipment is of the usual kind. A telephone, in connection with the central station, is placed on each section pole, and a key for the telephone is kept on each car in a box with a glass front, the key being obtainable by any one on breaking the glass. The box also contains an "earthing" switch and rubber gloves.

The earth switch is intended for use in the event of telephone or telegraph wires falling on the trolley wire, or in case of the trolley wire breaking. The cars, as a rule, have only the ordinary hand and electric emergency brakes, but six are fitted with Thomson-Houston brake controllers, one with the Westinghouse magnetic slipper brake, one with Milnes', and one with Spencer's slipper brake.

The following statement shows the growth of earnings :—

Year ending Sept. 29.	Car Receipts.
1895	£52,704
1896	59,959
1897	65,957
1898	95,527
1899	120,477
1900	151,702
1901	205,428

The passengers carried during the last yearly period were 44,820,830, equal to carrying the whole population of Leeds 100 times during the year.

As an incentive to careful driving, a bonus of 20s. is paid to each driver who, in the opinion of the Claims Committee, has been free from accident during the preceding six months. W. W. H. G.

231. *Sutton and Howth Electric Tramway.* (Elect. Rev. 49. pp. 623–624, Oct. 18, 1901.) — The Great Northern Railway Company of Ireland has equipped this tramway to connect the railway stations of Sutton and Howth. The system is overhead trolley, with continuous current at 500 volts. The boiler-room contains three boilers by Taylor & Sons, working at 160 lbs. per square inch. The feed-water is heated by a heater with vertical tubes connected to the exhaust. The engine-room contains three vertical compound non-condensing engines by Ernest Scott and Mountain. These drive directly at 350 r.p.m. three compound-wound dynamos, each of 125 kw. ; the compounding can be regulated by a switch. A boosting set of two negative boosters is driven by a motor ; the boosters give 160 amperes at 100 volts. A substation contains a battery of 250 Tudor cells, with a capacity of 200 ampere-hours, and a reversible booster, used for charging the cells, and for running in series with them. The battery switch, the motor-starting switch, and the booster switch are each operated by solenoids connected by underground leads to switches in the power-house.

The overhead construction consists of poles with short arms, carrying a single trolley wire 0·325 inch in diameter. Telephone and pilot wires are also carried on the poles. The positive feeders consist of lead-covered armoured cable of 0·15 square-inch section, 7 miles in length ; a return feeder of the same size, 2 miles long, is connected with the boosters.

The track is laid with bull-head rails weighing 72 lbs. per yard, carried on chairs resting on sleepers 2 ft. 8 in. apart. The gauge is 5 ft. 3 in. The rolling stock consists of eight double-decked cars, each capable of seating sixty-seven passengers. The trucks are double-bogie Brill, each with one Westinghouse motor. The controller used is B18 by the British Thomson-Houston Co. Three brakes are fitted—an electric brake, a Westinghouse air brake, and a hand-brake. The gradients are continuous and severe, reaching 1 in 16·7. G. H. B.

232. *Brooklyn Rapid Transit Company.* **C. E. Roehl.** (Street Rly. Journ. 18. pp. 322–332, Oct., 1901.)—This article contains a summary of the plant at present existing in each of the five stations belonging to the Company. The present plant appears to have a capacity of about 24,000 kw.; but arrangements are being made by which one of the existing stations will be closed, and about 36,000 h.p. of new machinery will be added in a new station. Some of the existing plant is of an old type, being belt-driven; full particulars are, however, given in all cases. The main interest lies in the outline which is given of the new station to be built in the Third Avenue, which will eventually supply about 32,000 h.p. In the first instance 24 boilers, of the water-tube type, by Aultman and Taylor, will be installed, each boiler having 6,500 square feet of heating surface, and a capacity of 650 h.p. There will be two steel chimneys, lined with firebrick, 217 feet in height. The engine-room will contain six 4,000-h.p. engines of the vertical marine type. Four of these engines will be connected to three-phase generators, working at 6,600 volts, and 25 cycles; the other two will drive ordinary railway generators. The engines and generators will have three bearings, one of which is an outboard bearing on the far side of the generator. The cylinders are of 42 inches and 86 inches in diameter, and the stroke is 60 inches; they work at a speed of 75 r.p.m. The diameter of the two engine bearings is 27 inches, and each is 42 inches long; the outboard bearing is 30 inches in diameter, and 56 inches long. In the generator, the diameter of the shaft, which is of hollow forged steel, is 35 inches. The 28-feet flywheel weighs 107 tons, and the crane will lift 50 tons. The alternate current will be transformed by rotary converters in substations; there will be eleven of 1,000 h.p. each, and five of 500 h.p. W. H. S.

233. *Portsmouth Electric Trams.* (Tram. Rly. World, 10. pp. 539–546, Oct., 1901.)—The site of the power-house is practically central. The engine-room is 119 feet long, 52 feet wide, and 52 feet high. It has a fireproof floor constructed on steel girders. There is a basement beneath for access to pipes, &c. The boiler-house is 65 feet long, 47 feet wide, and 55 feet high. The three Babcock boilers are fitted with superheaters. Three surface condensers are provided of the Admiralty type. Steel cooling towers have been erected, and furnished with direct-connected motor fans.

The plant consists of two 400-kw. sets and one 200-kw. set. The engines are by Yates and Thom, driving generators of the English Electric Manufacturing Company.

The track and overhead equipment is generally of the standard character. The thoroughfares are somewhat narrow, in one case being only 18 feet in width. W. W. H. G.

234. *Switch-gear of the Lausanne Central Station.* **K. P. Täuber.** (Elektrotechn. Zeitschr. 22. pp. 825–829, Oct. 3, 1901.)—The Lausanne Central Station contains five 400-h.p. units, giving three-phase current at 3,100 volts. The article describes the switchboards, switch, and instrument pillars, and the general scheme of connections. It is fully illustrated. G. H. B.

235. *Hydraulic Power Station at Colgate, California.* (Elect. World and Engineer, 38. pp. 583–586, Oct. 12, 1901.)—Water is taken from the North Yuba River, and carried in a flume, 7½ miles long, to a point 700 feet above the river; the drop in the flume is 13 feet to the mile. From the penstock five pipes, of 30 inches diameter, carry the water to the power-house; they

are of steel at the top and cast iron at the bottom. The plant consists of three sets of 3,000 h.p. each, and four of 1,500 h.p., consisting of Risdon Iron Works impulse wheels connected to the three-phase 60 ∿ Stanley generators. The wheels are governed by Lombard governors and deflecting nozzles. The pressure at present in use is 40,000 volts, and the plant is so arranged that this can be increased to 60,000 volts when required.

The transmission line to Oakland, a distance of 142 miles, consists of two distinct pole-lines, each carrying three wires arranged at the angles of an equilateral triangle, with sides of 36 inches. Transpositions of one-third of a turn are made every mile. One of the pole-lines carries three No. 00 hard-drawn copper wires, and the other three No. 0000 7-strand aluminium cables.

G. H. B.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

236. *Recent Tramway Practice.* **J. More, Jr.** (Tram. Rly. World, 10. pp. 497–509, Sept., 1901. Paper read before the Engineering Congress at Glasgow, Sept., 1901.)—This paper deals mainly with electric traction practice during the last five years, considering permanent-way construction over a longer period, this being of less recent development.

PERMANENT WAY. *Rails.*—The steel employed has changed from a 0·35 percentage of carbon to one of from 0·55 to 0·65, giving a much harder and more durable rail, yet sufficiently tough, with an ultimate tensile stress of 45 tons per square inch, with an elongation of 15 per cent. and a contraction of over 40 per cent. in a 2-inch test piece. Rails now weigh from 80 to 100 lbs. per yard, and are invariably of girder section. The standard length of 45 feet is sometimes extended to 60 feet, where transportation difficulties do not intervene. The sections have much improved through the relaxation, to some extent, of Board of Trade objections to wide grooves and broad treads, this being largely due to corporations adopting sections which would not have been allowed to a private company. Until recently rails were rolled with a much too obtuse angle at the shoulders or fish-bed. The author's suggestion of reducing this almost to a right angle was first adopted for the Cape Town Tramways, and this improvement has now become general. The author is averse to the use of sole-plates, and considers that the main point of good vertical stiffness is best obtained by the use of heavy fish-plates with good fish-beds, and a tight solid concrete bed under the plain rail flange. He advocates the use of fish-plates with six 1-inch bolts to each pair of plates. *Points and Crossings.*—Objection is taken to the practice of some American firms of making cast-steel points and crossings with special hard filling pieces of manganese steel, where the wheels of the cars drop. This involves a large surface of exposed metal with consequent danger to horses. The renewable filling pieces are also liable to work loose. As the authorities now permit a much larger metallic surface on the roads than formerly, chilled iron points can be made with sufficient body of metal to withstand the lateral shocks from heavy cars, and they are greatly superior in durability to cast steel. *Foundation.*—The method preferred by the author of laying a concrete foundation is to lay the concrete as truly level as possible, but about 1 inch lower than the finished level of the rail flange, and, when set, to place and level the rails, and pack from both sides. Plastering the haunch of the rails is

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

objectionable, as it neutralises the advantages derived from the elasticity of pitch grouting, which should always be used, besides facilitating the entry of water. *Paving.*—The setts are now laid quite closely, and this is found to be less dangerous to horses, instead of more so, as was anticipated. In macadam roads the paving at the margins should be finished with a straight joint to avoid trouble in rolling.

Traction Systems.—Reference is made to cable traction, which is of value on some routes with heavy gradients, but present-day traction is electric. The author considers that if a light, durable cell should be discovered which could be charged in about one-third of the time now taken, the accumulator system would supersede all others, but at present it is not financially practicable. Surface-contact systems have not yet passed the experimental stage, and the studs are objectionable in a roadway. The conduit system has yet to prove its financial advantages in this country. The author agrees with Kennedy that the large conduits used in America are unnecessary here, and considers that in his recent designs for the London County Council Kennedy has reduced the conduit to the minimum of cost and capacity.

Central Station Plant.—The author prefers the Galloway boiler, its thorough circulation giving a high efficiency and good steam-raising power. Water-tube boilers are of advantage in combined lighting and traction stations, as their greater steam-raising power can better cope with the concurrence of the two load maxima. They are also useful where space is restricted. Economisers are a necessity. Conveyors can be made profitable in some very large stations. Mechanical stokers are useful in avoiding black smoke, and generally advisable where first cost is not a primary consideration. The author disapproves of electric driving for feed-pumps, electric motors being out of place in the boiler-house. He advocates the supplementing of the feed-pumps by injectors and using them to feed through the economisers. The considerations governing the selection of the type of engine are considered, and illustrated by the results of trials. A typical generator specification is then given, followed by tables of the comparative results obtained on some important tramway systems.

Transmission System.—Great stress is laid on care in bonding, and the not uncommon practice of giving it out as piecework to ordinary mechanics is strongly deprecated. The author prefers the fastening of the Neptune bond to any other. Examples are then given of dimensions and physical tests of trolley-wire poles and of trolley wire. The importance of careful soldering of the trolley wire to the ears is strongly insisted on, and the amount of tension put on in erecting the wires should not be left to the judgment of the foreman of the gang, especially when erected in the summer, in which case too great tension will probably lead to many breakages when the temperature falls. The strength and tension of guard wires should receive due attention, or they may become an actual source of danger. There should be two lightning arresters on each half-mile of track, and, unless the ground plate can be "earthed" in running water, it should be embedded in fine coke. In discussing the cables the author gives the following as a useful test as to the fatigue which the insulation will stand in threading:—A piece of cable is wound round a drum three times in one direction and three times in the opposite direction. It is then immersed in water, and must stand a pressure of 2,000 volts alternating for 15 min. without breaking down. For cables of 0·2 square-inch area the diameter of the drum should be 1 ft. 6 in., and 2 ft. 6 in. for large cables. Illustrations are given of a manhole for drawing

in cables, and also of feeder switch-pillars, which should each be provided with lightning arresters.

Rolling Stock.—The four-wheeled car is most suitable for all-round work, owing to its economy in power as compared with the eight-wheeled bogie car, and it has more adhesion on severe gradients, owing to there being less distribution of the weight. The latter, however, runs more smoothly, is easier on the rails, and is preferable for high speeds and small curves. Motors are then discussed, and a sample specification of a 25-b.h.p. motor is given, with illustrations and curves. With regard to controllers, the author prefers the solenoid blow-out to the magnetic type, on account of the smaller damage by flashing. He considers that there is at present a tendency to the use of too many emergency brakes, adding to the weight of the car, and the confusion of the driver when an emergency occurs. The brakes advocated by the author are :—(1) An air-brake, which is an independent unit, and the most speedy, and therefore specially suited for emergencies. It should be applied to the wheels and used as the ordinary brake, more especially on descending gradients. (2) A hand-brake fitted as a slipper brake to act on the rails, and actuated by a screw spindle with a heavy hand-wheel, so as to give delicate application and act as little counter as possible to the wheel-brake. (3) An electrical emergency brake to act on the wheels or axle.

The paper concludes with some remarks on operation and general management, in the course of which the author points out the importance of the suitable location and distribution of car sheds in saving loss of time both of men and cars. G. W. DE T.

237. *Tramway Power Stations for Polyphase Plant.* **J. E. Woodbridge.** (Elect. World and Engineer, 38. pp. 532–536, Oct. 5 ; 592–594, Oct. 12 ; and pp. 638–641, Oct. 19, 1901.)—The author considers the case of a line with half-hourly service and having each car equipped with motors aggregating 50 h.p. For such a service, supplied from substations 10 miles apart, he would employ a rotary converter of 300 kw. in each substation, with a similar machine in reserve. The periodicity of the three-phase circuit is assumed to be 25, and the voltage of the main feeders from 10,000 to 15,000 volts, which latter is the highest which can be safely generated in the usual sizes of alternators without having recourse to step-up transformers. The step-down transformers in the substations he assumes to be of the air-blast type, the blowers being driven by small induction motors, and giving a pressure of about $\frac{3}{4}$ oz. per square inch. The whole of the substation equipment is closely considered, and many useful details are given of the actual buildings themselves—floor construction, wiring, attendants' quarters, &c. Regarding danger from fire, the author says that the location of substations is usually such as to expose them to much greater fire risks than generating stations. The added cost of fireproof construction per kw. capacity installed is, moreover, no greater in a substation than in the generating station, and the loss of revenue due to a line being shut down in case of fire warrants the added cost of incombustible construction. Regarding the conductors, the author is in favour of running them in the blast chamber and specially built flues, and having them bare and supported on "Redlands" porcelain insulators. Brick, tile, and concrete slab barriers are used between the leads. A long creepage distance is necessary between each wire and the wall of the building where exposed to the weather. This is provided by anchoring the outside line to a porcelain strain insulator of a type with eave-shaped corrugations both above and below the fastening of the wire. From this strain insulator the wire

passes upward into the building through a porcelain bushing with a corrugated top indoors and a petticoated lower portion out of doors. The building has an extension over these insulators not unlike a dovecote in appearance. Regarding the generating station the author is of opinion that the location of the switchboard at the end of the engine-room is not to be recommended, owing to difficulties of extension, as well as length of leads and distance from machines at the opposite end of the room. The distribution of electrical apparatus along the side of the engine-room opposite to the boiler-room wall almost invariably gives the best results. Since the travelling crane need not span the switchboard, oil switches, &c., these can be placed in a sort of lean-to, outside the crane and roof supporting columns, thereby giving a considerable saving in the cost of the crane and of the main roof trusses.

The articles are exceedingly well illustrated by fifteen line drawings.

E. K. S.

238. *Polyphase Tramway Power Plant.* **M. G. Starrett.** (Street Rly. Journ. 18. pp. 259–265; Oct., 1901.)—This paper deals with the engineering considerations involved in the design, and in the practical results obtained in actual operation, of the Metropolitan Street Railway of New York.

Practice has shown that for electric railway purposes, where a large amount of power is used, but where the amount of power needed near any one point is small, polyphase distribution is the most suitable system. In this instance a comparison between the cost of serving the district from one polyphase or two direct-current stations showed that the cost of feeders alone in the latter system made it prohibitory, whilst the use of several direct-current generating stations, which would have brought down the cost of feeders, was out of the question, owing to the cost of land. The cost of the generating plant would have been about the same for direct as for alternating current, the cost of the commutators in the one case being counterbalanced by the cost of the switching apparatus in the other. Eight out of the eleven generating sets are at present in operation.

The space per kw. at Ninety-Sixth Street power-house is 0·68 square feet in the engine-room, and 0·56 square feet in the boiler-room, total 1·24. These figures are said to be from one-half to one-fifth those obtaining in other stations [American stations with horizontal engines probably referred to]. Space is economised by using the same sized unit throughout.

Analyses of coal, oil, and flue gases are regularly made, the flue gas being taken from the back connection of the boilers. The water evaporated per lb. of coal is 8·4 lbs., the coal consumption per kw.-hour 2·65 lbs., and the water consumption per kw.-hour at switchboard, 22·41 lbs. (this includes all coal-hoisting, stoking, and auxiliary machinery); 14·9 lbs. of water are evaporated per i.h.p.-hour (including auxiliaries). There are 72 boilers, and the useful boiler-hours are 58 per cent. of the total—that is, out of 1,168 boiler-hours, 679 are useful, and 489 reserve. [See also Abstracts Nos. 1372, 1373, and 2112 (1900).]

F. B.

239. *Polyphase Distribution for New York Tramways.* **W. A. Pearson.** (Street Rly. Journ. 18. pp. 266–272, Oct., 1901.)—Notable as being the largest street railway system in operation, and distributing an unusually large amount of energy per square mile, a comparison of the costs of distributing from two direct-current stations, or from a single polyphase generating station with six substations, showed that the former would cost about £340,000 more than the alternating system. This includes the cost of real estate and of the

feeder system; the feeders alone would involve an additional cost of about £172,000. The feeder capacity is 26,000 kw. at 6,400 volts. The district served is 9 miles long by 2 miles wide. A storage battery is installed at each substation, having a capacity of about 25 per cent. that of the rotary converters. The battery is considered a very good investment. The efficiency of the distributing system, including the high-tension feeders, static transformers, and rotaries is 90 per cent. as shown by the difference in the records of the wattmeters in the power station, and those in the direct-current bus-bars at the substations. The high-tension feeder loss is from 3 per cent. to 7 per cent. Owing to the large number of instruments in use, and the need for accuracy, two men are employed to give their whole time to checking them. The method of checking is described. In all there are 750 switchboard instruments, including 84 recording wattmeters. In designing the system 16,500 watts (33 amps. at 500 volts) were allowed per car. The energy per car-mile is about 2,100 watt-hours at the substation board, including the lighting of car-houses, &c. Tests on individual cars show a consumption of 1,500 watt-hours per car-mile. Maps of the district are given showing the feeders, also load curves, e.m.f., and current diagrams. Sample sheets from the feeder and conduit record books are also given. [See also preceding Abstract.] F. B.

240. *Storage Batteries in Traction Power Stations.* **W. E. Harrington.** (Street Rly. Journ. 18. pp. 472–475, Nov., 1901. Paper read before the Amer. Street Railway Association.)—In this paper figures and curves are given showing the effect of a battery at the generating station in diminishing fluctuations of current in street railway circuits. An incidental advantage of the battery is that it acts as a very efficient lightning arrester. Batteries at substations, besides smoothing out fluctuations, result in a considerable economy of copper in the feeders, and the constancy of line voltage attained diminishes motor depreciation; the engines also work more steadily and therefore more economically. The site of the sub-battery station is of great importance. The formula—

$$\text{Cost of copper} = 304 \left(\frac{c_1 d_1^2}{V_1} + \frac{c_2 d_2^2}{V_2} + \frac{c_3 d_3^2}{V_3} \right) \text{ dollars}$$

is given, where c, d, and V are the mean current, volts lost, and length in miles of the three feeders, viz., power station to substation, substation to near end of line, and substation to extreme end of line. $d_1 + d_3$ and $d_2 + d_3$ are constants; the cost should be worked out for different values of d_2, and with V_2 and V_3 bearing different ratios to V_1, and the length of d_2 which gives the lowest cost of copper gives the best position for the sub-battery station. B. P. S.

241. *Storage Batteries and 60-Cycle Railway Rotaries.* **E. L. Reynolds.** (Street Rly. Journ. 18. pp. 402–404, Nov., 1901.)—This paper contains a description of the method in which storage batteries are employed at Hamilton, Ontario, to steady the load on rotary converters supplying current for railway work, so that it becomes possible to run incandescent and arc-lighting circuits and alternating motors from the same high-tension transmission circuit which supplies the rotaries. Transmission is at 22,000 volts, three-phase, the current being generated at 2,400 volts, two-phase, and stepped up; the length of the transmission line is 34 miles. At the substation are static transformers, three rotary converters (each 300 kw., 66

periods, with 550 volt secondaries), and a storage battery of chloride accumulators with a capacity of 400 amperes at 550 volts, which is run in parallel with the rotaries on the railway circuits. Voltage curves are given showing the variation of pressure on one of the 110-volt lighting circuits (*a*) when the battery is in use, (*b*) when it is off, the local conditions being the same in each case. The first curve shows a maximum variation of 5 or 6 volts in a run of 5 hours, the second of about 22 volts in the same time. Other advantages of the battery, besides that of regulating fluctuations, are pointed out, such as the obviating of a temporary shut-down in case of slight accidents to machinery, and the possibility of operating the railway service from the batteries alone in the hours of light load, thus ensuring an all-night service without the need of running the rotaries continuously. B. P. S.

242. *Modern Electric Railway Switchboards.* **G. U. G. Holman.** (Street Rly. Journ. 18. pp. 407–416, Nov., 1901.)—Slate and marble for switchboards should be carefully selected and tested before use. Slate should not be used for working pressures over 1,000 volts. Enamelled slate is better than marble for railway working. Marble for pressures over 3,000 volts should be polished on both sides. With the aid of insulating bushes, marble may be used for pressures up to 15,000 volts. The current density in the jaws of knife switches should not exceed 50 to 100 amperes per square inch. Bolted contacts may take from 100 to 200 amperes, and laminated brush contacts up to 500 amperes per square inch. Tables of the sizes of main and equaliser cables for various sizes of generators are given, as well as of the necessary distance between metal parts at a p.d. of 500–600 volts. Six inches is the maximum distance required. Full details are given of the construction and equipment of standard railway switchboards. For large outputs it is better to put all the positive main and equaliser switches close to the machines, and to have only negative switches on the board. With the negative bus-bar earthed it is better to equalise on the positive than on the negative pole, to guard against a possible internal earth in the machine; the resulting damage is likely to be much less in the former case. This does not apply to rotary converters.

The connections of a high-pressure three-phase switchboard are discussed, with the methods of working in use. Relays in the low-pressure ammeter circuits are used to operate the circuit-breakers. The rotary converter connections are also explained. When circuit-breakers for high pressures are placed at a distance from the board, automatic visual signals are necessary to show their condition. In designing these circuit-breakers it is necessary to know, not only what their normal duty will be, but also the capacity of the whole station, which might be thrown upon one of them in the event of a short-circuit occurring. Methods of synchronising are discussed, and the two-voltmeter system is recommended. Great importance is attached to making ample and suitable provision of space in the station for the cables and switchboards. The article is fully illustrated. A. H. A.

243. *Third-rail Interurban Electric Railways.* **M. Hoopes.** (Street Rly. Journ. 18. pp. 387–389, Oct., 1901. Paper read before the New York State Street Rly. Assoc., Sept., 1901.)—The author refers to the New York, New Haven, and Hartford Railroad [see Abstracts Nos. 218 and 716 (1898), and Abstract No. 366 (1899)], and the Albany and Hudson Railway [see Abstract No. 1432 (1901)], and gives data showing that the cost per mile of track of third-rail construction is about £682, while that of overhead trolley-wire construction is about £884, the former showing a saving of 23 per cent. The

track must be carefully fenced in, unless street railway tracks are used at the termini, in which case the cars must be operated on the trolley system at these points. To change from the third rail to the trolley wire requires about 15 seconds. The author objects to guards over the third rail, and states that the danger inherent to its use is small compared with the other dangers unavoidable in railway working. Objections are raised to placing the third rail between the track rails; it should be outside one of the latter, and elevated several inches. The insulators should be mechanically strong, and should not be rigidly attached to the third rail. The latter should be made of a special low-carbon steel, which may have a specific resistance as low as 12·9 microhms per c.c. By giving the third rail a sufficiently large cross-section—generally 80 lbs. per yard—copper feeders are rendered unnecessary, the converting stations being 10 to 12 miles apart. The collecting shoes should be spaced so that they do not pass over joints in the third rail simultaneously. At level crossings the rail is interrupted, the circuit being completed by underground cables. The greatest weather trouble with the third rail occurs in sleet storms, when a film of ice is formed which it is very difficult to remove quickly. Snow gives no trouble. A. H. A.

244. *Multiple Unit System for Electric Railways.* **M. Kubierschky.** (Elektrotechn. Zeitschr. 22. pp. 558-563, 1901.)—The system here described has been designed by the author and E. Volkers for the Union Electricity Co., of Berlin, and is described in the German Patents Nos. 114048 and 119972. Each carriage has its own controller, the various controllers being operated by means of an auxiliary motor, which is worked by the driver. It differs from the Sprague system [see Abstract No. 395 (1898)], and that of Siemens and Halske (German Patent No. 104940), inasmuch as the motor is mechanically connected to the controllers by the action of solenoids, which are connected in series with the auxiliary motor; and the various controllers are operated by the motor in the one direction only, movement in the reverse direction being produced by means of a spring or dead weight. The article contains an elaborate description of the various details, together with several drawings and illustrations. The method has been applied on a local railway in Baden between Karlsruhe and Ettlingen. W. H. S.

245. *Report of Committee on Standards of the American Street Railway Association.* (Street Rly. Journ. 18. p. 483, Nov., 1901. Paper read before the American Street Railway Association.)—The report is accompanied by sectional drawings illustrating the recommendations of the Committee with respect to rail sections, car wheels, axles, journals and brasses, car bodies, and the electrical and overhead equipment.

A T-rail is recommended as the most desirable under any conditions, and it is stated that with a rail-head and car-wheels of the form and dimensions set forth a tramway can be operated at a minimum cost for track and maintenance, without interfering with the pavement in cities, and with safety on suburban roads. G. W. DE T.

246. *Economy of Electric Traction on Railways.* **C. A. Carus-Wilson.** (Elect. Rev. 49. pp. 493–494, Sept. 20, 1901. Abstract of a paper read before the Glasgow Engineering Congress.)—The author compares the actual running expenses of English steam railroads with the calculated costs of electric traction. Taking the Great Northern Railway as a representative line, and allowing for the high price of coal, the running expenses per train

mile are shown to be 11·85d. The estimated running expenses for electr traction are 4·89d., while the actual expenses of the Liverpool Overhe Railway are 5·17d. W. R.

247. *Tests of the Scheinig and Hofmann System of Rail-Bonding.* **Kvetensky.** (Zeitschr. Elektrotechn., Wien, 19. pp. 543–545, Nov. 1 1901.)—This paper gives particulars of some tests made on the electric stre railway at Linz-Urfahr with this rail-bond, for a description of which s Zeitschr. Elektrotechn., Wien, 19. p. 113, 1901. The cost of a 16-cm. sho retaining the copper-bond and fish-plate, fitted to the rails, is K. 14·04, a that of a shoe 20 cm. long, without fish-plate and without copper-bond, K. 16·64. C. K.

248. *The Conveyance of Goods on Electric Trolley Lines.* **A. H. Gibbing** (Tram. Rly. World, 10. pp. 576–578, Oct., 1901. Paper read before th British Association at Glasgow, Sept. 14, 1901.)—The author advocates the fr use of trolley lines for the conveyance of traffic, instead of the canals, railway and horse lurries at present employed.

The ideal scheme for the conveyance of goods in such an area as Sout Lancashire should comply with the following conditions: (1) The good should be loaded direct from ships, warehouses, or depôts, and deposite without further handling at their ultimate destination; (2) In order to carr out the above condition transit should be on highways, and special siding run into warehouses, mills, &c.; (3) There should be no special stoppages delay in transit from the loading point to the destination; (4) The servic when necessary, should be continuous for the whole twenty-four hours pe day, excluding perhaps Saturdays, Sundays, and public holidays, but even o these days a service should be available if urgently required; (5) No shun ing operations should be necessary, and hence marshalling is avoided. N more than two trucks (motor and trailer) should be marshalled together (6) One or two special forms of trucks should be used for all classes of goods (7) The service should be expeditious, but not necessarily entailing a high ra of speed; (8) The system should possess every facility for the transference goods (without handling in piece) to or from railway trucks or horse lurries (9) The line for conveyance of goods should not be in any way designe exclusively for that purpose, but it should not interfere with any passenger o ordinary road traffic; (10) No alteration in the existing gradients of the roa ways should be necessary; (11) The maximum weight to be carried on eac truck should be not less than 9 tons; (12) The charges should be reasonabl economical, and should compare more favourably with American an Continental railway rates than do the present British railway rates.

Electric trucks have the same advantage as horse lurries, in that the can be moved immediately they are loaded and replaced by empty one In railway traffic there is an enormous waste of time in marshalling th trucks, to say nothing of the expense of moving the merchandise from lurri into the depôts, from depôts to trucks, and again, at the destination, fro trucks to depôt and depôt to lurries. By a well-thought-out system electric traffic traction along the main roads and sidings into the vario works, most of this waste would be entirely done away with. The auth makes a comparison of the time taken to deliver goods by ordinary railway an lurries from Liverpool to Bolton, 29 miles, and makes it 24 hours; where with an electric service, it could be done in about 4½ hours. Two mil cartage is taken at 1s. 3d., and railway carriage, with station terminal charg

at 9s. 7d. per ton-mile for Class 1 merchandise, cotton, &c. Two kinds of trucks are proposed—one on the lines of a Pittsburg express car for conveying miscellaneous goods and for local traffic, and the other to be an application of the principle adopted by the South-Eastern Railway and the Lancashire colliery railways. The South-Eastern Railway employs a detachable van, fitted with steel lifting ropes, which rests upon the top of a flat railway truck. The collieries use coal waggons fitted with three detachable boxes, each box carrying 2½ to 3 tons of coal. When it is required to discharge the coal a box is lifted by lifting rings, and a bottom door opened, or, the usual tip method is adopted. The comparative sizes of the trucks, &c., are as given below :—

Proposed electric trolley truck	22 ft. by 6½ ft.
Ordinary railway truck	16 ft. by 7 ft. 10 in.
Ordinary two-horse lurry	17½ ft. by 7¼ ft.

A train would consist of one motor truck and one trailer, and they would together carry 18 to 20 tons. They would be of good design and not nearly so unsightly as the horse-driven lurry, while great public benefit would accrue from the relief of the streets from lurry traffic. The Surveyor of Tydesley, U.D.C., finds the cost of road maintenance for four years averages £233 2s. per mile per annum, exclusive of scavenging. It has been shown that the greater proportion of the road wear is from horses' shoes, as illustrated in the following table :—

General Results of Observations of Causes of Road Wear and Deterioration.

Kind of vehicle and load.	Wear due to atmospheric causes.	Wear due to wheels.	Wear due to horses' feet.
	Per cent.	Per cent.	Per cent.
London and Birmingham. Coaches : Weight, 16 cwt. to 18 cwt., empty ; loaded, 45 cwt. Speed, 8 to 12 miles per hour	20	20	60
Waggons : Weight, 25 cwt. ; loaded, 92 cwt. Speed, 3 miles per hour...	20	35·5	44·5

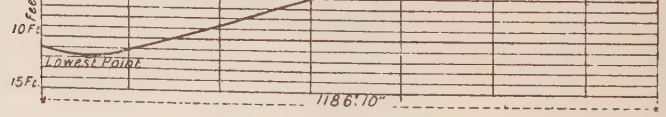
E. K. S.

249. *Tramway Track Construction.* **E. H. Packe.** (Street Rly. Journ. 8. p. 386, Oct., 1901. Paper read before the N.Y. State Street Railway Association, Sept., 1901.)—The author, who is one of the engineers of the Brooklyn Heights Railroad Co., thus describes their standard construction in streets where the pavement is granite block on concrete foundation. The street is excavated to the sub-grade, which is levelled off with sand. On this are laid the ties, 6 in. by 8 in. by 7 ft., with tamped foundations. On these are spiked the 9-inch girder rails, 60 feet long with brace tie-plates every third tie, Weber joints being used for splicing. Portland cement concrete is rammed between and around the ends of the ties, forming a solid bed of 6 inches above the sub-grade between the tracks and rails, and for 2 feet outside. On this is laid an inch of sand, in which the granite blocks are bedded. Another form of construction consists in placing the rails on concrete beams ; these beams are 10 inches by 12 inches in section, and are placed beneath each rail. The author's experience shows that this latter

form of construction is much more expensive, and that the wear of the r is also much greater. Drawings are given showing the wear of rails on b forms of track after five million cars had passed over them. W. H

250. *Tramway Costs.* (Street Rly. Journ. 18. p. 340, Oct., 1901.)— elaborate table is given with this article showing the receipts and expens under a large number of items, of the Metropolitan Street Railway Compa of New York for the three years 1899–1901. The Company owns cal electric and horse trams, the accounts for each being given separately. the last year, *i.e.*, from June 30, 1900, to June 30, 1901, on the electric lines passenger receipts were 33·74 cents per car-mile, and the operating expen 13·56 cents. On the cable trams, these figures were 36·31 cents, and 18 cents respectively; and on the horse trams, 22·7 cents, and 19·19 cents. T operating expenses on the electric lines are made up as follows: maintenan of track, 0·88 cents per car-mile; repairs of cars, 1·73 cents; power includi all power-house expenses, 1·78 cents; transportation, including wages motor-men, conductors, inspectors, car-cleaners, &c., 7·02 cents: off expenses, compensations, and general expenses, 2·15 cents. W. H.

251. *Tests of Roller Bearings.* **W. H. Booth.** (Tram. Rly. World, pp. 557–562, Oct., 1901.)—The author points out that by the use of wheels a axles the tractive resistance on rails is decreased some 98 per cent., so t about 2 per cent. only, representing some 11 or 12 lbs. per ton, is the reducti that is possible by the use of a perfect roller bearing. With the rapid accele tion required in tramway practice, the amount of starting current that can saved by roller bearings forms a very small proportion of the whole. ascending grades the extra power required will be practically the same wheth plain or roller bearings are employed. On descending grades the car may ta less current on very gentle slopes, but on steeper gradients braking will



necessary, and this will be greater with roller bearings than with plain one with greater wear of wheel rims and shoes, but less axle wear. Outside the points the economy will simply be equivalent to the power saved on a lev road.

In making the tests described in this paper a straight section of line w selected with a slope sufficiently flat to prevent a car from acquiring dangerous rate of speed, when started from rest at the top of the slope, a allowed to drift freely down-hill under the influence of gravity. The starti effort was that due to a rapid snatch, on and off the first notch, of the starti handle. The post distances and the slope are shown in the accompanyi diagram. The times of passing each post were noted, and the distanc measured between the posts. One set of tests was made by allowing t cars to drift down the slope under the action of gravity, and with simi conditions of weather, load, &c. The cars tested were exactly similar, exce that one had ordinary white metal bearings, the other the bearings to

ested. The load was about 1,800 lb. Owing to the speed of the record as varying with the amount of winding up of the springs, the record strips did not correspond in length with the actual times, but this introduced no serious error, as the areas of the diagrams were measured by a planimeter, set, in each case, to the length of the diagram, so as to measure the mean height. The results are given in the accompanying tables.

TABLE I.

ROLLER BEARINGS, CAR A.

1	2	3	4	5	6	7	8	
No. of Notch.	Length of Paper.	Apparent Equivalent Time.	Actual Time.	Maximum Amps.	Volts.	Average Amps. of Current.	7 × 4 Amps. × Time.	Remarks.
	Inches.	Seconds	Seconds.		500		Amp. Seconds.	
1	6⅜	127·5	137	6		4·700	643·8	
2	7⅜	147	133	5		3·375	448·8	
3	7¼	145	128	5		3·870	495·3	
4	7¼	145	127	5		3·437	436·5	
5	6⅜	127·5	110	8		6·060	666·6	
6	5¼	105	87	19		12·500	1087·5	
7	4¾	95	82	21·75		12·900	1058·0	
8	5⅛	102	88	21·5		12·000	1056·0	Controller put slowly on.
Drift	6¼	125	112	—	Voltage on each day practically identical.	—	—	
,,	5⅞	117	102	—		—	—	
,,	6⅜	127½	110	—		—	—	

TABLE II.

WHITE METAL PLAIN BEARINGS, CAR B.

1	2	3	4	5	6	7	8		
No. of Notch.	Length of Paper.	Apparent Equivalent Time.	Actual Time.	Maximum Amps.	Volts.	Average Amps. of Current.	7 × 4 Amps. × Time.	Economy of A over B.	Remarks.
	Inches.	Seconds.	Seconds.		500		Amp. Seconds.		
1	8	160	155	7		5.810	900·2	24·48%	Brake probably on slightly.
2	6⅞	137	139	7		6·000	834	46·18%	
3	6 3/16	124	133	7½		6·125	814·4	39·18%	
4	6 5/16	132	130	7½		6·125	796·2	45·18%	
5	5 5/16	112	115	9		7·500	862·4	22·7 %	
6	4¼	85	86	18½		15·300	1301	16·41%	
7	4⅛	85	84	20		15·200	1277	17·15%	
8	4⅜	87	84	21·5	Voltage on each day practically identical.	15·125	1270·8	16·9 %	Controller put slowly on, but more quickly than on car 2.
ift	10	200	194	—		—	—	—	Brake probably on slightly.
	7 5/8	152·5	160	—		—	—	—	
	7½	150	157	—		—	—	—	

It will be seen that the roller bearings had very little effect on the ti occupied in each uphill run. The power, however, is considerably less the case of the car provided with them. If for each car the sum be taken the amounts of current in notches 2, 3, 4, the mean difference is 2·523 amper which appears to be the saving due to the roller bearings, and approxima closely to the 2·742 amperes found as the mean difference of the two cars notches 6, 7, and 8, these latter being controller positions with the two motors in parallel.

In the series running it works out to 354·7 ampere-seconds saved in run of 1,187 feet, which means in this case nearly 4 h.p., corresponding to extra traction resistance of about 15 lbs. per ton. The total weight of ea car was about 7¼ tons.

The average current taken per car on this line is about 14 amperes, that a saving of 2½ amperes is about 17 per cent. This apparent econo will, however, be reduced in the ratio of the time of standing and of dow hill running with no current, to the total time. The author estimates therefo the maximum economy, on the basis of these tests, as not exceeding 10 p cent., while it may fall as low as 6 or 8 per cent. G. W. DE

252. *Block Signal Apparatus.* (Elect. World and Engineer, 38. pp. 500–50 Sept. 28, 1901.)—This paper describes the mechanism in the post devis by C. W. Coleman, of the Hull Signal Company. The post carries hor and distant signals. An electromotor is geared, by a double set of redu tion gears, to the axle carrying the crank to which the up-and-dow rod of the semaphore is connected. The gears are kept from revolvi backward by a ratchet. The crank operating the up-and-down r of the signal is not permanently fastened to the axle upon which it turns, b is free to turn independently of the gear, except when held by an electr magnetic clutch. When a signal is to be pulled to "clear," the motor a clutch circuits are closed, and when the signal is at "clear," a cam switch co nected with the rod opens the motor circuit, and the signal arm is kept position by the clutch, and a ratchet acting on the motor gearing. To put t signal to "danger," the clutch is released, and the rod, which is heavier tha the arm, overbalances the latter and brings it back to its normal positio There are cranks and clutches for two signals. The motor is a ⅛ h. Crocker-Wheeler. The power required for clearing a signal, about 4 amper at 6 volts for ten seconds, is obtained from caustic potash batteries. Half t amount of energy is required as compared with early types, with the sam factor of safety on the counterweight. E. O. V

253. *English and American Railway Signalling.* **J. Pigg.** (Elect. Re 49. pp. 503–505, Sept. 27 ; 539–540, Oct. 4 ; 582–583, Oct. 11 ; 663–664, Oc 25 ; and pp. 701–705, Nov. 1, 1901.)—The author describes the developme of railway signalling in America, and contrasts the methods now in use in th country with those employed in England. One of the most general is know as the Controlled Manual System. One operator releases the lever of t other, but the process is governed by the train. The releasing apparatus arranged so that it can be operated but once for each train passing throu the block controlled by it, and then only on condition that the signal of t next succeeding block is restored to danger behind the previous train. Fo merly the train worked a treadle, but the latter suffered from the heavy blow Now the "track circuit" is used. Two insulated parallel rails form independent circuit with a small Daniell gravity battery and a relay. Whe

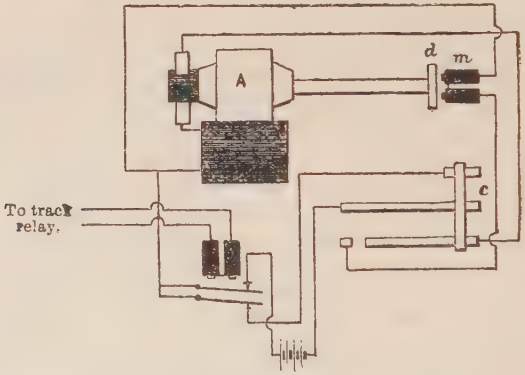
ain passes the current is diverted from the relay, and the tongue of the tter influences the signal circuit. There is special mechanism by which the ver of, say, "A's" signal is locked in the danger position by the armature of n electromagnet controlled and operated by "B." A special circuit is rected between those points for the operation of the apparatus, and at each lace an indicator is provided, which shows "clear" when neither has given ermission to lower the other's signal, and "blocked" when one of them has one so. At "A" the special circuit includes the electromagnet only, the rmature of which locks the signal lever. At "B" the circuit is completed rough the tongue of a relay operated by the track circuit relay, and also rough a "plunger" or circuit breaker. The effect of "plunging" is to break own the special circuit by which the lock is operated, and it remains in this ondition until the train signalled passes on to the track circuit, which, of ourse, is outside of the "block." Until the train has passed on to the track ircuit, and remade the locking circuit, further use of the plunger has no ffect, and the operator at "B" is thus prevented from releasing "A's" signal or a second train, even if he inadvertently goes through the operation of lunging.

A purely automatic system is that known as the "over-lap." In this rrangement the signal at the entrance to a section is kept at danger by the ain in the block until it has passed the signal governing entrance into the cceeding block, a certain predetermined distance, both signals being held danger during the time the train is on the overlap section. A supplementary gnal to those already referred to is known as the "distant," or cautionary gnal. This signal is essentially a repeater, in that it indicates the position of e "home" or stop signal at the entrance to the block ahead. The overlap stem, since it ensures the placing of two signals to danger behind a train ter it has passed into the next block ahead, is considered to minimise the sk of collision with a succeeding train which has passed the first of the two gnals referred to. This action is accounted for by the rule that, where utomatic signals are in use, trains may pass them, when at danger, at caution, ter a stop of one or more minutes, as the rule requires. Hence the overlap stem enables two signals to be kept at danger behind the first train until the tter is some distance within the protection of the last one. The disadvantage that drivers may be tempted to pass signals carelessly when at danger, when ware that the previous train may be actually out of the block governed by e signal.

In the most recent practice signals are operated by compressed air, parately provided and supplied, as in the Westinghouse system; or by lectric motors, as in the Hall system. In the former the track relay governs e valves of a compressed-air motor through the medium of an electro-agnet. The positive action of the motor duly lowers the arm. It is turned to danger by means of a counterweight. The Hall system provides r the operation of "distant," "home," and advanced or starting signals in aces where it is desirable to draw a train forward for shunting or other rposes before the block ahead is clear of the preceding train. Besides this, arning bells are provided at all switches in a section. Signals are operated electric motors of about $\frac{1}{8}$ h.p. The motor is attached to the signal above the unterweight, which it works by means of a stranded wire cable, the other d of which is attached to a drum in gear with the armature shaft, so as to fect a reduction of speed in the ratio of 25 to 1. The arrangements are ewn in the accompanying diagram. A is the motor, *m* a magnetic brake ting upon an iron disc, *d*, attached to the armature shaft, and *c* is a com-

mutator for altering the circuits automatically. The commutator is driven by a worm and gearing on the drum shaft. When the relay is first energised, the commutator is as shown, and current passes through the motor, which lowers the arm. As the motor runs, the commutator changes the circuits, in effect, as if the vertical passed gradually to the opposite end, breaking the motor circuits, and passing the current from the battery through the brake coils—which are of high resistance and take comparatively little current—instead. The magnetic brake draws up the motor, and holds it after the signal arm has been lowered. The signal is raised to danger again, when the armature of the relay is released, by the counterweight, and the commutator resumes the position shown by the rotation of the armature under the action of the counterweight. In this position of the commutator the motor circuit is short-circuited as long as the relay is not energised. Hence the current, generated by rotation of the motor armature by the falling counterweight, acts as a brake, and ensures the signal taking its position without undue shock.

Attempts have been made to cause a signal to physically prevent the entrance of a train into a block already occupied, by independent operation



of the air-brake; for instance, by a glass tube above the engine, which is broken by the impact of an arm projecting from the signal, or by a special projection on the track being made to close the throttle valve; but they have not generally met with success.

Methods and systems of signalling in use in this country:—The essential difference between British and American methods consists in the control of the signalling. In the States, in the higher development of signalling, control is exercised by the train itself by virtue of its position. With trifling exceptions, the highest development in this country is comparable only with the controlled manual in America. There are reasons why the use of automatic signalling should be more pronounced in the United States than in this country. Automatic signalling, whilst the ideal system for lines where long distances have to be run between diverging points, fails in that it exercises no selective action, and is therefore unsuitable for use at junctions. In this country junctions are numerous, and the operations at such points must necessarily be selective. There are, however, many places where automatic signalling might be used, though they do not necessarily form consecutive sections. E. O. W.

254. *Electrolysis by Earth Returns.* **W. Leybold.** (Elect. Rev. 49. pp. 492–493, Sept. 20, 1901. Paper read before the Glasgow Engineering

Congress.)—Electric currents were detected in water pipes near Durlach, 6 kilometres from the nearest generating-station, which were certainly not due to external influences. Such currents can only be due to voltaic action between the iron and the lead which is used for jointing. The author gives an account of the destruction of gas pipes at Hamburg, where the ground contains 0·0006 to 0·04 per cent. of sodium chloride. The electric trams were started in 1894, and were completed in 1895. In the latter year, corrosion of the wrought-iron pipes was discovered at points where they passed under the rails. The 1-inch pipes are covered with canvas soaked in boiled tar, but this method of protection does not seem to be very effective; in fact it favours the corrosion when once this has begun, because blisters form between the iron and the tar, containing saline liquid which is favourable to electrolysis. No corrosion has been observed in the pipes of cast-iron. The destruction has been remedied by laying down return-feeders which have reduced the pressure between the rails and the gas pipes in one of the streets from 5 volts to 0·45 volt. W. R. C.

255. *Long Runs of Electric Automobiles.* **H. F. Joel.** (Elect. Rev. 49. pp. 864–865, Nov. 22, 1901.)—A table is given of six recorded runs on one charge, concluding with the recent run of 190 miles of a Krieger car with Fulmen cells. According to the figures given the weight of the cars ranged between 1 and 2·5 tons; the weight of the battery relatively to the total weight, from under 40 per cent. to a little over 50 per cent.; the useful load, *i.e.*, passengers, relatively to total weight, from 10 per cent. to 20 per cent.; and the watt-hours used per ton-mile from 115 to 140. The figures relating to each run are discussed in some detail, and the author expresses the opinion that the most economical distribution of the total weight of a loaded car should be as follows: Car body, motor, &c., one-third; batteries one-third, and one-third for passengers or load. He calculates that under such conditions the cost for current would be one penny per ton-mile of useful load, with electrical energy at threepence per unit. E. J. W.

ELECTRIC LAMPS AND LIGHTING.

256. *Czeczowiczka's Lighting System.* **J. Löwy.** (Zeitschr. Elektrotechn., Wien, 19. pp. 503–505, Oct. 20, 1901.)—In this system, which requires the network for supplying private consumers to be separated from that for the street-lighting, the lamps which are to burn all night, and those which are only to burn for the first half of the night, can be arranged on the same circuits, and the half-night lamps extinguished from the central station without it being necessary to employ a separate controlling circuit or a special switch. This is effected, according to one method, by arranging the lamps which are only to burn during the first half of the night in series with choking coils, the lamps which are to burn all night being connected directly across the mains. By supplying a direct current to the mains up to midnight, and an alternating current after midnight, the half-night lamps can be extinguished as required. The dimensions of the choking coils are calculated in the paper so as to give a mean loss per lamp of slightly over 5 per cent., distributing the loss over the whole time of lighting. An alternative method is given in which an alternating current is used first, condensers being arranged in series with the half-night lamps. Suitable central-station arrangements are also discussed. C. K. F.

257. *Arc Lighting.* **W. D'A. Ryan.** (Amer. Electn. 13. pp. 522–524, Nov., 1901.)—The candle-power of arc lamps is expressed in several ways including, amongst others, the mean c.p., the mean hemispherical c.p. (the lower hemisphere), and the mean c.p. over a selected area. Such ratings are of little use for determining the commercial illuminating value of lamps for street-lighting purposes.

Street illumination curves are given in the paper, plotted from measurements taken with direct current open and enclosed arcs, and an enclosed alternating arc.

The curves show the intensity of illumination which will fall on objects normal to the rays of light at different distances from the pole.

The peculiarities of open, enclosed, and alternating lamps are compared and candle-power curves given which show the variations in c.p. from the time of striking to the feeding point.

The greatest variations are in the open arc, the following figures being a summary of results on which the curves are based. The c.p.s given are the maximum.

Conditions.	Open Arc.	Enclosed Arc.
Hissing arc over-feeding	300 c.p.	—
Short arc just after striking	600 „	525 c.p.
Normal arc	1,250 „	600 „
Long arc just before feeding	1,400 „	570 „

Better distribution also is obtained with enclosed arcs, and there is not that excess of light nor dense shadow common to the open type.

Curves of distribution of illumination are given, based upon various sizes of street lamps, of the alternating enclosed type. A certain degree of illumination, as determined by a luminometer, was fixed upon as a minimum midway between the two lamps. Tests were then made with various lamps to ascertain the distance D, to which this illumination could be projected. The curves are based on the following figures :—

Current and Energy per Lamp.	D.	Lamps per Mile.	Watts per Mile.	Size of Carbon.
7·5 amp. (485 W.)	247 feet	10·68	5,180	$\frac{1}{2}$ inch
6·6 „ (425 „)	227 „	11·62	4,940	$\frac{1}{2}$ „
5·4 „ (350 „)	197 „	13·40	4,690	$\frac{1}{2}$ „
4·4 „ (285 „)	178 „	14·85	4,235	$\frac{7}{16}$ „

The distance apart of two lamps is of course double that given in the distance column. F. B.

258. *Regulating Devices for Series Alternating Current Circuits.* **J. H. Hallberg.** (West. Electn. 29. pp. 272-273, Oct. 26; and pp. 288–289, Nov. 2, 1901. Paper read before the Ohio Electric Light Assoc., Aug. 21, 1901, at Put-in-Bay.)—A general description is given of regulating devices for arc lamps run in series on an alternating current circuit. A detailed practical account is also given of the series alternating current system with compensators and shunt wound enclosed arc lamps. The author divides alternating current enclosed arc lamp series systems into three classes. In the first class differentially wound arc lamps are used, equipped with automatic cut-outs, and hand and automatic switches are employed which bring in and cut out choking coils for equalising the pressure. This is not

a practical method when more than twelve lamps have to be operated in series. Sometimes a transformer is used, with terminals on its secondary coil giving various potentials, so that the pressure in the circuit can be varied by a hand switch. This system is complicated, and the regulation is not good. In the second class a constant current transformer is employed, the secondary being generally a floating coil counterpoised by a weight. The change of pressure is effected automatically by the repulsion between the primary and secondary coils. In this system it is necessary to use differentially wound arc lamps. The efficiency of these lamps is stated to be about 90 per cent., and that of the 100-light (about 60 kw.) constant current transformer generally employed, about 96 per cent. This system is limited to cases where the circuits are practically always fully loaded. Sometimes the constant current transformer has a device actuated by any change in the secondary current, which cuts in or out turns in the secondary so as always to maintain the proper p.d. in the lamp circuit. The power factor and current are practically constant at all loads, and the efficiency of a 50 or 100 light circuit is about 87·5 per cent. In the third system compensating choking coils are used in series, and shunt wound enclosed arc lamps are found to be the most suitable. A full description is given of a "G. I." automatic regulator for this circuit. Its efficiency is 98·8 per cent., and it regulates to within 0·2 of an ampere. The author considers that this system is the most economical. He says that experiments are being made with condensers to try and increase the power factor of arc-lamp circuits.

A. R.

REFERENCES.

259. *Determination of Price of Electric Supply.* **K. Wilkens.** (Elektrotechn. Zeitschr. 22. pp. 1001–1003, Dec. 5, 1901.)—This is a supplement to the paper referred to in Abstract No. 1199 (1901) and describes how the quantities required by the equation there given can be determined in practice. Examples of the different classes of consumers are given. C. K. F.

260. *Electric Tramway Tractive Effort and Power Diagram.* **A. G. Hansard.** (Electrician, 47. p. 937, Oct. 11, 1901.)—A description of its use accompanies the diagram, which enables the following information to be obtained by inspection:—1. Given the weight of the car and the gradient, the "drawbar pull" is shown. 2. Taking into account the speed, the brake horse-power required to drive the car may be found. 3. If the efficiency of the electrical equipment is known, the kilowatts to be supplied to the motors are shown.

261. *Best Form of Car for City Service.* **E. Chamberlin.** (Street Rly. Journ. 18. pp. 465–468, Nov., 1901. Paper read before the American Street Railway Association.)

262. *Tests of Nernst Lamps.* (Elect. Engin. 28. pp. 726–728, Nov. 22, and pp. 765–767, Nov. 29, 1901. Translation.)

263. *Storage Batteries for Automobiles.* (Elect. World and Engineer, 38. pp. 538–546, Oct. 5, 1901.)—This paper consists of an illustrated description of various types of American accumulators specially intended for use in autocars. In most cases some account is given of their design and method of manufacture, curves of discharge p.d. and figures of output for weight. The following makes are dealt with: Sperry, Clare, Perret, Gould, Chloride, Willard, Porter, American, Reuterdale, and Osburn. E. J. W.

TELEGRAPHY AND TELEPHONY.

264. *Cable Speed-Rate Conversion Tables.* **E. Raymond-Barker.** (Elect. Rev. 49. pp. 865–867, Nov. 22, 1901.)—Tables of multipliers by which statements of telegraphic speed, whether in siphon recorder or in Morse code, may be reduced from one mode of expression to another with due regard to the varying space factor. A formula is constructed and forms the basis for the tables as follows:—The element (e) is the fundamental unit, where each contact (siphon recorder) = 1e, each *dot* (Morse) = 1e, each *dash* (Morse) = 3e, each space between contacts = 1e, and each space between words = 7e. The number of elements per letter, denoted by v, has for traffic purposes been shown to be 7·16 for recorder, and 9·12 for international Morse. And x, the number of words of N letters signalled per minute, being equal to the ratio of the number of elements signalled per minute, to the number of elements per word of N letters, allowing for spaces between letters and words, is determined from the following equation, in which W is the number of words, and L the number of letters received in T minutes:—

$$x = \frac{\{Lv + 4(W-1)\}\frac{1}{T}}{vN + \frac{4}{vN}}.$$

For practical purposes, a sufficiently close approximation is obtained by writing—

$$x = \frac{(Lv + 4W)\frac{1}{T}}{vN + \frac{4}{vN}}.$$

E. O. W.

265. *Induction Troubles in Telephone Cables.* **J. H. West.** (Elektrotechn. Zeitschr. 22. p. 829, Oct. 3, 1901.)—The author investigates the induction troubles which occurred in the London and Birmingham telephone cables having two pairs of cores laid or twisted together, and attributes them to the several cores being unequally braked or stretched during the twisting; for example, three of them may be wound spirally round the fourth, which is the most tightly stretched. He makes the following suggestions: (1) That the drums should rotate as easily as possible, and that the twist should be as long as is permitted in view of the flexibility which the wires and cable must have during the manufacture and laying; (2) that, at definite intervals, the wires of one loop should be interchanged when necessary, or all the four wires interchanged; (3) that successive lengths of cable should be alternately twisted right- and left-handedly, and also that, in cables with 400–500 wires, the connections of the several lengths should only be temporarily made at certain places, so that the wires can be interchanged, and so eliminate any induction troubles that may be found to exist. C. K. F.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

FEBRUARY 1902.

GENERAL PHYSICS.

266. *Dial Slide-Rule.* **P. Weiss.** (Soc. Franç. Phys., Séances, 2. pp. 77–79, 1901.)—The instrument, which is constructed by I. Werlein, is to facilitate multiplication and division. It consists of a dial with a logarithmic graduation on its circumference, and two pointers, the indicator and the multiplier; the latter can be moved independently, but takes part in all the movements of the former. H. B.

267. *Manipulation of Liquefied Gases in Sealed Tubes.* **H. Moissan.** (Comptes Rendus, 133. pp. 768–771, Nov. 11, 1901.)—The author investigates the temperatures produced by the evaporation of solutions of solid carbon dioxide in various liquids. Acetone was found to be the most suitable, and with this solvent the temperature fell to -98° C. When dry air, previously cooled to -80° C., was led into the mixture, the temperature was -110° C. If it is desired to examine the action of a liquefied gas on a solid substance in a sealed tube, the temperature should be lowered until the gas solidifies, when the tube may be exhausted and easily sealed. Glass tubes of 1·5 mm. interior and 6 mm. exterior diameter will withstand pressures of over 300 atmospheres.

In order to examine the products obtained, the tube should be cooled down again until the gas solidifies, and the point then broken off. By connecting with a pump, and gradually allowing the temperature to rise, the products may be fractionally distilled. Certain precautions must be taken; in particular the gases should be pure, and no trace of moisture must be present. When hydrogen is evolved the method is useless, as the tubes burst; if the tubes are cooled below -200° C. they generally break on attaining the ordinary temperature. W. C. B.

268. *Viscosity of Sulphur.* **C. Malus.** (Annal. Chim. Phys. 7. pp. 491–574, Dec., 1901.)—The author died during this research. This account was compiled by Duhem after the author's notes. The sulphur was crystallised from carbon disulphide, dried and pressed for months, ground and fused in glass tubes, afterwards sealed. The paper does not confine itself to the viscosity [see Abstract No. 1773 (1900)]. Ordinary sulphur, S_1, contains gaseous SO_2. This gas can be expelled by heating the sulphur for several hours above 300° C., or at 185° C., by sending a current of CO_2 through the liquid. The

sulphur, S_1, has then passed into S_2, which is reconverted into S_1 when heated in the presence of SO_2. The two modifications differ in colour, viscosity, &c. When heated to 357° C. for fifteen minutes only and then cooled to 100° C., S_1 passes into the third modification S', which still retains the SO_2, and can be reconverted into S_1. When sulphur is fused at 120° C. in a partial vacuum, solidified, and remelted, the resulting liquid column is full of gas bubbles which can be removed by shaking; but on repeating this experiment eighty times, when the tube broke, the author still observed the formation of gas bubbles. H. B.

269. *Hydrostatic Pressure.* **W. Ramsay.** (Archives Néerlandaises, 6. pp. 349–351, 1901.)—The paper describes an attempt made to determine whether fine-grained particles, having incessant pedetic motion in a liquid, exert hydrostatic pressure. The density of a colloidal solution of arsenious sulphide in water is determined, first by a hydrostatic method, and then by the pyknometer. The same is done for barium chloride. In both cases the pyknometer is found to give a higher value, but the difference is so small as to be comparable with the errors of observation. The author concludes that the particles by their impacts on the sinker exert hydrostatic pressure. J. W. P.

270. *Equations of Flow of Fluids.* **D. J. Korteweg.** (Archives Néerlandaises, 6. pp. 1–24, 1901.)—The necessary modification of the equations of motion of a compressible viscous fluid, when account is taken of the capillary forces due to considerable but continuous variations of density, is here considered, and the theory of capillarity on the hypothesis of a continuous variation of density is discussed. The memoir is too mathematical to be abstracted. R. E. B.

271. *Small Elastic Displacements.* **F. Kohlrausch** and **E. Grüneisen.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 46. pp. 1086–1091, Nov. 14, 1901.)—Reference to the work of Bach is made, in which the connection between stress and strain is expressed by the formula $\varepsilon = A\sigma^m$, where ε is the relative extension or contraction, σ the force per unit area, and A and m are constants of the material. This law, or a similar one with a series of powers, is said to express the connection of stress and strain more accurately than the old law of simple proportion. The importance of such a formula for technical purposes is admitted, but the theoretical importance claimed by Bach is doubted. The validity of extending the supposition at all beyond the experimental range is denied, and the need for investigation, especially in the low values, is insisted upon. Experiments by the authors upon the flexure of rods of cast iron, wrought iron, brass, and slate are given. In these an optical method is used, and the strains are measured with great exactitude. For wrought iron the law of simple proportion is found to hold. A less complete adherence to this was found in the case of brass, but the deviation was much less than that found by Bach. Slate, within the limits experimented upon, acted as a completely elastic body, and showed an unexpectedly high elasticity modulus. For grey cast iron, agreement with Bach's results is found. The formula $y/x = A + B\sqrt{x}$, where x and y are the stress and strain, A and B elastic constants, is suggested as satisfying the results more closely than Bach's formula. The question of discontinuity in the passage from extension to compression is also touched upon. J. W. P

272. *On the Maximum Dynamical Stress in Elastic Systems.* **T. Levi-Civita.** (N. Cimento, 2. pp. 188–196, Sept., 1901.)—This memoir begins with a reference to Beltrami's law that the true measure of the force to which the molecular cohesion can be subjected at every point of an elastic body is the value assumed at the point by the potential of the elastic forces. This superior limit is denoted in the present paper by P_d, and the writer proposes to prove that—

$$P_d = 2P_s + E + 2\sqrt{P_s(P_s + E)},$$

where E is the total energy of the body in its initial state, and P_s is defined as follows: If π denote the elastic potential, and $P = -\int \pi ds$, taken throughout the body, then P_s is the value of P corresponding to the position of static equilibrium under the action of the given forces. If U denote the work done by the external forces on displacements denoted at every point by u, v, w, and T be the kinetic energy, $E = T_0 + P_0 - U_0$, and the general equations of the theory of elasticity lead to the equation—

$$T + P - U = E, \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

the external forces being supposed independent of the time. The author next considers the superior limit of P for the case in which (3) is the only equation. This limit is called P′, and the author says that evidently $P_d \leqq P'$. The value of P′ is found by reducing to zero the variation of P, given $T + P - U = E$, according to the usual method, writing—

$$\delta P + \lambda T(T + P - U) = 0.$$

Writing μ for $\lambda/(1 + \lambda)$, this leads to the equation—

$$\mu^2 - 2\mu P_s = E;$$

whence—

$$\mu = 1 \pm \sqrt{1 + E/P_s}.$$

The roots must be real. The superior limit sought is found by taking the positive sign, or $\mu = 1 + (1 + E/P_s)^{\frac{1}{2}}$. The author then finds the result proposed, viz.—

$$P' = \mu^2 P_s = 2P_s + E + 2\left\{P_s(P_s + E)\right\}^{\frac{1}{2}}.$$

He further concludes that the displacements u', v', w', for which $P = P_d$, the maximum dynamical stress, are in general uniquely determined, and proportional to u_s, v_s, w_s, those of the statical stress, namely—

$$u' = W_s\left\{1 + (1 + E/P_s)^{\frac{1}{2}}\right\}, \text{ \&c.}$$

The only case excluded is that in which no external forces act, there being then an infinite number of sets of displacements which give to P its maximum value E. Two examples are given. S. H. B.

273. *Temporary Set in Wires.* **C. Barus.** (Phys. Rev. 13. pp. 283–306, Nov., 1901.)—From Kelvin's work we know that mechanical strain is accompanied in solidsby viscosity and slip between the particles. But magnetisation produces strain; hence we should expect that the phenomena of magnetostriction have viscosity and slip involved in them. If so, the theories of Kirchoff, Helmholtz, and Maxwell on the subject of magnetostriction (in which viscosity is ignored) must be faulty in part. The investigation is made

as follows: Subject a soft iron wire to a fixed torque, corresponding to a definite deflection (δ) on a scale. Now magnetise the wire; the deflection changes, and when the field is removed the deflection is found to differ from δ. The author finds by investigation, (1) that in the presence of an impressed strain a longitudinal field produces increased rigidity and temporary set; (2) temporary and permanent set occur in twisting, just as in magnetisation.

The author suggests that the Ewing model representing magnetic strain should have the viscosity element introduced into it. A number of curves and tables are given. [See also Abstract No. 881 (1901).] P. E. S.

274. *The Frictional Resistance of Ether.* **M. Thiesen.** (Deutsch. Phys. Gesell., Verh. 3. 13. pp. 177–180, 1901.)—Experience confirms Maxwell's theory, that radiated light exerts, in the direction of its motion, a pressure equal to the energy per unit of volume. It is probable that the pressure so experienced by any body would be modified by motion of the body, and the author deduces this effect from the laws of radiation, following the same method as in the deduction of Wien's so-called law of displacements. If a train of waves falls, with angle of incidence $\cos^{-1}c$, on a plate in motion, the wave-length λ undergoes a change, $2\beta\lambda c/(1-\beta c)$, where β is the ratio of the velocity of the plate to that of light. The result which he obtains, using only the lowest powers of β, is that, for time dt and volume U,

$$\partial\lambda = \lambda\frac{fvdt}{U}\left(\mp\frac{\beta}{3} - \frac{1}{4}\beta^2\right).$$

Two cases are considered; first, that in which the plate forms a closed or infinite surface, and is affected only on one side; secondly, that in which it moves in free space. The first case leads to Wien's displacements, the second, writing $y' = \beta v$ (the velocity of the plate), leads to a pressure per unit area, $p = 2\frac{y'}{U}S$, where S is energy. This is the pressure sought. It is shown to be very small, amounting for the earth's surface to not more than 1,000 kg., whence it follows that the influence of this resistance on the length of the year is of the order—

$$4{\cdot}3 \times 10^{-22}T^4 \text{ seconds},$$

T being the temperature in degrees Cent. S. H. B.

275. *On Absolute Motion.* **V. A. Julius.** (Archives Néerlandaises, 6. pp. 285–286, 1901.)—The author points out that when laws of motion are stated as representing actual results of experience, the motion must be relative to some definite medium or space. If we have two spaces or modes of defining space, one, A, defined by the co-ordinates x, y, z, with centre C, and the other, B, by the co-ordinates ξ, η, ζ, with centre O, and if the x, y, z co-ordinates of O be α, β, γ, and the direction cosines of the ξ, η, ζ axes referred to the x, y, z axes be a, a', a'', &c., then he expresses d^2x/dt^2 in terms of $\alpha, \beta, \gamma, a, a', a''$, &c., and shows that if there exists a potential for the field A, there is no potential for the field B unless a, a', a'', &c., are independent of the time.

In the writer's view, the medium to which all motion ought to be referred is the ether, and by absolute motion we should understand motion relative to ether. S. H. B.

276. *Determinations of Gravity on the Australian Continent.* **G. v. Neumayer.** (Archives Néerlandaises, 6. pp. 333–348, 1901.)—The author begins with a brief survey of pendulum work, pointing out a time of inactivity subsequent to Bessel and a new impulse given by Sterneck and others. The need for experiments in the Southern Hemisphere is pointed out, and the work of the Royal Society of Victoria, Australia, is referred to. A description of the author's experiments made in Melbourne forty years ago is given, and comparison is made between his results and those obtained at different places in Germany by means of similar apparatus. The pendulum was of the type suggested by Bessel as an improvement on the Kater-Bohnenberger instrument, and a specially constructed vertical comparator was used for determining the distance between the knife-edges. The values of l and g found were respectively, when reduced to sea-level, 0·9929120 metre and 979·965 $\frac{\text{cm.}}{\text{sec.}^2}$. Determinations made thirty years later by Baracchi are quoted, and a synoptic table of results obtained for Melbourne by Gubert, Elblein, Baracchi, Love, and the author is given. J. W. P.

277. *Reduction of Plumb-Line Observations.* **F. R. Helmert.** (Archives Néerlandaises, 6. pp. 442–447, 1901.)—The effect of hill ranges upon the value of gravity at different levels is considered, and formulæ are worked out. The case of a long range of rectangular section gives the result—

$$\Delta_1 - \Delta_0 = Kh_0 \left\{ \log \frac{4c^2+1}{c^2+1} + 4c \tan^{-1} \frac{1}{2c} - 2c \tan^{-1} \frac{1}{c} \right\},$$

where h_0 is the height, ch_0 the breadth of the section of the range, $\Delta_1 - \Delta_0$ the difference of deviation for bottom and top, and K a gravitation constant. Similarly an escarpment gives the result—

$$\Delta_1 - \Delta_0 = Kh_0 \left\{ \frac{\pi\beta + \beta^2 \log \beta^2}{\beta^2+1} - \log (\beta^2+1) \right\},$$

where β is the tangent of the angle of inclination to the vertical, and the rest of the notation is as before. Numerical results for the south slope of the Alps are appended, by which it is shown that $\Delta_1 - \Delta_0$ may have a maximum value of 5″. It is concluded that the results are not serviceable for effecting the reduction from Δ_0 to Δ_1 by observing the value of g at the foot of the range. J. W. P.

278. *Tides in the Macassar Strait.* **J. P. van der Stok.** (Archives Néerlandaises, 6. pp. 137–147, 1901.)—The results of observations of the tidal constants at the following stations are given: Macassar, Donggala, Pontoli, Balik Papan Bay, Mocara Djawa, Samarinda, Batoe Panggal, Boeloengan. These figures extend from 1895 to 1899, and are illustrative of peculiarities in the amplitudes and phases of the tidal components in these regions. After comparing all the results, the author concludes that the diurnal wave moves from north to south in the Macassar Strait, but with a velocity much less than that predicted by theory, and that the resultant semi-diurnal wave is not propagated in the strait at all, but is rapidly extinguished. The hypothesis is put forward that the tidal movement in the strait is the resultant of two elementary waves which, moving in the opposite direction, interfere differently as regards the diurnal and the semi-diurnal wave. J. W. P.

279. *Hygrometry.* **G. Guglielmo.** (Accad. Lincei, Atti, 10. pp. 193–202, Nov. 3, 1901.)—The paper describes a wet bulb method in which the constant is determined with accuracy by combining the results of observation with an ordinary wet bulb with those derived from a similar bulb wetted with a solution, say of sulphuric acid, of known vapour tension at the given temperature. There is a discussion of experimental errors and of means for ensuring compensation of these. A. D.

280. *St. Maurice Metcorological Observations during* 1900. **R. Gautier.** (Archives des Sciences, 12. pp. 265–300, Sept., 514–534, Nov., and pp. 587–601, Dec., 1901.)—In the fortifications of St. Maurice on the Rhône, observations are taken at two second order stations, Savatan and Dailly, and two pluviometer stations, l'Aiguille (elevation 1,446 m.), and Lavey (lower down). The temperature means are calculated from the arithmetical means of the three daily readings at 7 a.m., 1 p.m., and 9 p.m., and also by counting the 9 p.m. reading twice. Temperature inversions between the two stations, which differ in elevation by 563 m., are most frequent in December. The annual barometric means for the two stations are 702·9 and 656·6 mm., the extremes 715·8 mm. (December 16, 1900) and 636·9 (January 29th). The nebulosity is greater in winter than in summer. September is the clearest month. The maximum rainfall was observed at Dailly, 1,126 mm. on 193 days; most snow fell at l'Aiguille, 395 cm. on 59 days. References are made to Geneva and to the Great St. Bernard. H. B.

281. *Sun-spots and Planetary Disturbances.* **Birkeland.** (Comptes Rendus, 133. pp. 726–729, Nov. 4, 1901.)—In continuation of the author's previous attempts to trace any existing influence of the gravitational action of the planets on the production of sun-spots [see Abstract No. 1245 (1901)], he has examined the records from 1892–1896. After considering the facts with relation to Mercury, Venus, Jupiter, and Saturn, the conclusion is that the eleven-yearly period is not dominated by planetary disturbances.

C. P. B.

282. *Observations during Total Solar Eclipse, January* 22, 1898. **J. N. Lockyer, Chisholm-Batten,** and **A. Pedler.** (Roy. Soc., Proc. 68. p. 6, March 5, 1901 (Abstract); Roy. Soc., Phil. Trans. 197. pp. 151–227, Oct. 8, 1901.)—The paper contains a full report on the preparations, instrumental equipment, spectroscopic and other observations, and discussions of these in relation to laboratory work. The chief spectroscopic instruments employed were two prismatic cameras, of 6 and 9 inches aperture. The photographs obtained with the 6-inch instrument have been reduced, and a table is included of the determined wave-lengths of 856 lines between $\lambda 5896(D_1)$, and $\lambda 3663$, with their probable origins, obtained from comparison spectra photographed in the laboratory with the same instrument provided with a collimator and slit.

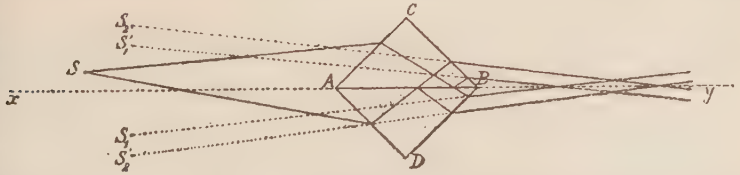
The coronal radiations have been classified into three groups, distinguished by having their maxima of intensity in different position angles. The three radiations at $\lambda\lambda 5303{\cdot}7$, 3987, and 4359·5 are typical of the three groups. Reproductions of the corona photographs and the spectra with the prismatic cameras accompany the paper. C. P. B.

LIGHT.

283. *Cornu's Criticisms of the Revolving Mirror Method of Measuring the Velocity of Light.* **H. A. Lorentz.** (Archives Néerlandaises, 6. pp. 303–318, 1901.)—Cornu, in a recent paper [see Abstract No. 776 (1901)], throws doubt upon the trustworthiness of results obtained by this method, on the grounds—(1) that the revolving mirror may be expected to drag the luminous beam with it to a small extent, and thus make the deduced velocity too small; (2) that the beam incident on the fixed mirror moves across it with a velocity comparable to that of light; (3) that the aerial vortex around the revolving mirror may modify the path of the rays. As regards (1), the author shows, by a direct application of geometrical optics, that the effect of the rotation is to alter slightly at each instant the distance between the centre of the revolving mirror and the image formed by reflection, but not to alter the direction in which this image lies; the angle of reflection is therefore not modified. As regards (2), he calculates that the velocity with which the beam traverses the fixed mirror was 0·0013 of the velocity of light in Michelson's experiment, and 0·032 in Newcomb's, and maintains that, even if much greater, it would not affect the directions of the reflected rays. A long discussion follows respecting the influence of diffraction, leading to the inference that diffraction impairs the sharpness of the final image, but does not displace it. As regards (3), the author maintains that the inequality of density of the air in the vortex, being symmetrically distributed round the axis of revolution, will not tend either to advance or retard the direction of either the incident or reflected beam; and that even if the distribution is unsymmetrical, its influence on the beam as sent out will be exactly compensated by its influence on the returning beam. Finally, as regards the dragging of waves of light by the vortex, Foucault's assumption of $1-1/v^2$ as the factor of dragging, applied to a supposed velocity of 200 metres per second of the revolving air, would only make a difference of 12 cm. per second in the deduced velocity of light.

A. E.

284. *Application of Govi's Camera Lucida.* **A. Lafay.** (Comptes Rendus, 133. pp. 920–921, Dec. 2, 1901.)—The property of the prism ABCD, that the images S_1, S_2', and S_2, S_1' coincide only when the plane of half the silvered surface AB contains the source S, is employed in an arrangement for testing scales and planes. Two sources are placed 3 metres apart, with the prism



midway, the plane AB being on the line joining the two sources, which are viewed through the prism by two telescopes, and two mirrors placed at 45° to the joining line. The prism is provided with a micrometer screw, and a pointer to touch the plane being tested, and an accuracy of 0·01 mm. is easily obtained. [See also Abstract No. 1415 (1900).] G. E. A.

285. *Metallic Reflection of Ultra-Violet Radiation.* **P. G. Nutting.** (Phys. Rev. 13. pp. 193–202, Oct., 1901.)—The paper contains a detailed study, with photographs, of the spectrum as reflected from various metals glass, quartz, cyanin, carbon bisulphide, benzine, and other liquids. The reflecting power of silver falls off to a rather sharp minimum of 10 per cent between 320 and 324 $\mu\mu$; and corresponding to this the spectrum between 310 and 340 is quite freely transmitted by a coating of silver on quartz so thick as completely to absorb all other radiation between 800 and 185. There is also another minimum (less than 10 per cent.) of reflection at 185 $\mu\mu$. The reflecting power of other metals, notably mercury, remains high and nearly constant, falling off but slightly in the neighbourhood of wave-length 185. Glass does not show metallic reflecting power in the region in which its absorption is very great; its properties in this respect are like those of solutions. A. D.

286. *Radiation of Black Bodies.* **F. Paschen.** (Ann. d. Physik, 6. 3 pp. 646–658, Nov., 1901.)—This is a controversial paper, defending the author's conclusions [see Abstract No. 1049 (1901)] against O. Lummer and E. Pringsheim [see Abstracts Nos. 1290 and 2356 (1901)]. A. D.

287. *The Green Ray.* **W. H. Julius.** (Archives Néerlandaises, 6. pp. 385–389, 1901.)—As is well known, the last rays of the setting, or first rays of the rising, sun sometimes appear green or bluish green. The explanation which first suggests itself is that the green ray is due to dispersion resulting from astronomical refraction. Bessel's tables give for the deviation of a ray by the earth's atmosphere 2094″ near the horizon. For air the refractive index n_D is 1·00029289, and $n_F - n_C = 0{\cdot}00000295$, whence we have for the dispersive power $\frac{n_F - n_C}{n_D - 1} = \frac{1}{99}$. The violet and blue rays are strongly absorbed by the atmosphere, and the length of the green portion of the spectrum may be taken as half the interval F to C. Hence, near the horizon we should expect to see the sun edged by a green border of width $\frac{2094''}{200} = 10''$. At the tropics the sun descends 15″ per second, which would make the visible duration of the green ray $\frac{2}{3}$ sec. The times quoted by observers are generally greater than this, and vary considerably. The author therefore does not consider this explanation satisfactory, adding further that it does not account for the rarity of the phenomenon. He suggests another explanation depending on anomalous dispersion produced by free ions in the upper regions of the atmosphere. A. E.

288. *Application of Maxwell's Curves to Choice of Inks for Three-colour Printing and Light-filters.* **R. S. Clay.** (Roy. Soc., Proc. 69. pp. 26–60 Nov. 8, 1901.)—The curves found by Sir William Abney are employed. In three-colour printing those parts where no red is to be reflected are printed with an ink which absorbs red, but reflects all other colours. This will be a bluish green ink. In the same way, parts reflecting no green are printed with a pink ink which absorbs green, and parts reflecting no violet with a yellow ink which absorbs violet. The author finds it is important that the three absorption bands, red, blue, violet, corresponding to the three inks should join abruptly end to end, and not overlap. A moderate admixture of white with the tints is not perceived by the eye; addition of black makes the

colours "dirty." In production of colour by successive absorption, the loss of light proceeds by geometrical progression, not by successive subtraction. This is important in "process" three-colour printing, for there the inks are always printed full strength, and the tint is regulated by the size of the dots, that is, by the area covered by the ink. It is practically impossible to control the relative placing of dots of different colours. This will be immaterial if the spectral absorption regions of the three inks do not overlap, but if they do overlap, then where dots of different colours coincide there will be blackness, and the colouring will only be correct when the dots fall clear of one another. Further reasons for using inks with abrupt absorption are that the colours will be purer, and that variation in the amount of ink from impression to impression will not be so important, thus avoiding a great practical difficulty. Assuming that the absorptions should be abrupt, the author proceeds to discuss the best limits, and places them at about λ49 and λ59. He finds that to make the luminosities balance, the absorption band of the green-absorbing ink should be a good deal narrower than the region covered by the green sensation. Thus the tints of the inks will not be truly complementary to the three-colour sensations. The red-absorbing ink should nearly match the green at λ50·3. A study of the curves for theoretical inks shows that the light-filters for three-colour printing should be entirely different from those used for three-colour projection. A theoretical ink is defined as one which is perfectly transparent until the absorption commences, and then is perfectly opaque. As this condition is rarely fulfilled in practice, the author determined curves for actual inks experimentally. By means of Abney's Colour Patch apparatus he measured, throughout the spectrum, the proportion of light of each colour that was reflected by several commercial inks. One pink ink (Fleming's No. 1303) fulfilled the theoretical conditions satisfactorily, also one yellow ink (Fleming's No. 1271), but all the blue inks were found too opaque in the green. A. E.

289. *Mechanical Theory of Vision.* **A. Pizon.** (Comptes Rendus, 133. pp. 835–837, Nov. 18, 1901.)—For the usual theory of vision based on a chemical action exerted by light the author proposes to substitute a *mechanical theory*. In all the visual organs of vertebrates and invertebrates the pigmentary granules which always accompany the visual cells are always animated by rapid movements comparable to those of certain micrococci. The general presence of these granules in immediate contact with the visual cells, and the constancy of their movements, lead to the supposition that they serve as intermediaries for the excitation of these visual cells. The granules obtain their energy from light under the form of a vibratory movement, which they transmit in their turn to the cones or to the rods with which they are in contact. The molecular disturbance thus received by the visual cells has only to propagate itself along the optic nerve to the nervous centres in the brain. J. J. S.

290. *Double Refraction in Solutions of Colloids.* **B. V. Hill.** (Phil. Mag. 2. p. 524–527, Nov., 1901.)—Former experiments showed that when dilute solutions of gelatine and gum-arabic in water are strained by continued movement they become doubly refracting [see Abstract No. 36 (1900)]. The present paper deals with strain produced statically. The dilute jellies were placed in thin brass tubes closed by glass plates at the ends, and were strained by squeezing the tubes between clamps so that their cross-section was elliptical. As the double refraction decreases rapidly with increase of

temperature, the tubes were surrounded by ice for from 16 to 48 hours, th plates at the ends being protected from dewing. Solutions of 0·3 grm and 0·5 grm. in 100 c.c. were employed. A solution of 0·2 grm. showe only a trace of double refraction after 48 hours in ice. A 0·1 grm solution gave effects after 120 hours. From the results it is seen that th double refraction increases with the compression up to a certain poin beyond which it remains stationary, and then diminishes. Thus the solution behave like solids capable of sustaining only a very small amount of strain When this amount is exceeded, disruptive action takes place, and the strai diminishes. The solid structure grows with the time, and more rapidly in th more concentrated solutions. There are indications that the structure doe not grow uniformly throughout the liquid at earlier stages, but afterward becomes more homogeneous. Depolarisation appears, but greatly decrease at a later stage. The fact that the plane of polarisation is not alway rotated in the same direction might be explained by supposing interna strains due to non-homogeneity to be actually relieved by the compression.

A. E

291. *Resolving Powa of Echelon Spectroscope.* **P. Zeeman.** (Archive Néerlandaises, 6. pp. 320–322, 1901.)—This is an attempt to furnish some dat for the comparison, desired by Rayleigh, between the actual resolving powe of a spectroscope and that given by the theoretical formula. The observation were taken with an echelon spectroscope by Hilger, having 30 plates 7·8 mm thick, with 1 mm. width of step. Defining resolving power as the valu of $\lambda/d\lambda$ for bare separation, its theoretical value is $\frac{\kappa nt}{\lambda}$, where n denotes th number of plates (plus one, if there is also an air space equal in width to on step), t the thickness of a plate, and $\kappa = \mu - 1 - \lambda \frac{d\mu}{d\lambda}$. For the green mer cury ray ($\lambda = 5460$) this gives $3{\cdot}8 \times 10^{-6}$ as the theoretical value of th limiting $\frac{d\lambda}{\lambda}$. In absence of knowledge of the difference of wave-length of the fine mercury lines near 5460, the green radiation of thallium was observed, with the result that, of two faint lines near the strong one, the one at distance $\frac{d\lambda}{\lambda} = 21 \times 10^{-6}$ was easily seen, but the one a $\frac{d\lambda}{\lambda} = 3 \times 10^{-6}$ could not be detected. The theoretical limit (λ being 5440 is $3{\cdot}75 \times 10^{-6}$. The green line of cadmium ($\lambda = 5086$) consists of two components, for which, according to Fabry and Pérot, $\frac{d\lambda}{\lambda} = 5 \times 10^{-6}$ and the theoretical limit is $3{\cdot}5 \times 10^{-6}$. This test was suggested, but was not made. The author thinks the most promising method for applying tests of gradually increasing severity, is by gradual variation of the strength of a magnetic field, and quotes Blythswood and Marchant [see Abstract No. 1019 (1900)] in support of this contention.

A. E.

292. *Properties of Certain Systems of Photographic Lenses.* **R. Sissingh.** (Archives Néerlandaises, 6. pp. 390–403, 1901.)—The method developed by Bosscha is employed to give a simple treatment of the properties of simple lenses, tele-objectives, and hyperachromatic lenses. For an infinitely thin lens without a diaphragm, the luminous intensity is proportional to D^2/F where D is the diameter and F the focal length of the lens. For the same

case with a diaphragm, the luminous intensity is given by the expression $IS\rho^2/\left(1-\frac{\xi'}{\xi}\right)^2$, where I is the intensity of the object, S the aperture of the diaphragm, ξ the distance from object to principal focus, ξ' the distance from diaphragm to same focus, and ρ is an optical constant representing the power of the system. Particular cases of this result are considered, and then the tele-objective is discussed. This consists of two systems of lenses, the one convergent and the other divergent, placed at some distance apart. Expressions for the focal distance and magnification are worked out, and the following advantages are claimed for them: (1) The same magnification as in the case of simple lenses is secured at greater distances; (2) the image distance is smaller under corresponding circumstances. The size of the dark chamber of the camera can thus be reduced. Also the perspective is less exaggerated in the image. The case of deformation of the images produced by symmetrical and semi-symmetrical objectives is then considered; and lastly hyper-achromatic lenses are dealt with under three heads: (*a*) Both constituents positive; (*b*) one positive, the other negative; (*c*) both negative.

J. W. P.

293. *Distribution of Energy in Spectrum of Acetylene Flame.* **G. W. Stewart.** (Phys. Rev. 13. pp. 257–282, Nov., 1901.)—This paper contains a determination of the distribution of energy in the spectrum of the flame, found by means of the spectrometer and radiometer. Observed and corrected curves of intensity are given for the cylindrical flame from a single-tip burner, and for the flat flame from a two-jet burner. The radiant efficiency of the cylindrical flame was found to be 0·100, while that of the flat flame was found to be distinctly higher.

E. C. C. B.

294. *Spectroscopic Determinations at Total Solar Eclipse, January* 22, 1898. **J. Evershed.** (Roy. Soc., Proc. 68. pp. 6–9, March 5, 1901 (Abstract); Roy. Soc., Phil. Trans. 197. pp. 381–413, Nov. 16, 1901.)—Detailed particulars are given of the complete examination of a series of spectra photographed during the total eclipse of the sun at Talni, India. Ten photographs were obtained at various stages of the phenomenon, the exposures being given in relation to the position of the moon so as to record the spectra of prominences, chromosphere, or corona. The instrument used was a small prismatic camera, the objective having an aperture of 50 mm. and focal length of 890 mm.; outside this there were adjusted two crown-glass prisms each of 60° refracting angle. The effective aperture of the prisms was about 42 mm. Immediately before totality (20 secs. and 10 secs.), photographs were obtained of the Fraunhofer spectrum furnished by the last segment of the photosphere. These served as reference spectra in the subsequent reductions. After this, the chromospheric spectrum at second contact was obtained; the negative shows 313 lines, the wave-lengths and origins of which are given in tabular form. Measurements of the arcs of many of the chief lines indicate a depth of 1″·3 for the gaseous stratum producing the "flash" spectrum, and the total depth of the chromosphere is given as 8″·2 when measured from hydrogen arcs, and 11″·6 from calcium arcs. A photograph taken just after this stage shows only the upper chromosphere and larger prominences. A conspicuous feature of the spectrum of two of these latter is a long band of continuous radiation, beginning near λ3668, where the ultra-violet hydrogen series ends, and extending indefinitely into the ultra-violet. A plate exposed for 40 secs. near the middle of the eclipse shows, in addition to the chief corona line at λ5303·3, a

second near λ3388, with the maxima of intensity at similar positions. A lengthy discussion is included dealing with the assignation of origins to the recorded lines, and the arrangement of the elements found into groups according to their atomic weight. Three plates accompany the paper, showing the varying spectra of the solar surroundings during the progress of the eclipse. C. P. E.

295. *Banded Spectra of Metals.* **W. N. Hartley** and **H. Ramage.** (Roy. Dublin Soc., Trans. 7. pp. 339–352, Oct., 1901.)—Photographs are given of the flame spectra of many metals which show very beautiful bands, and from their results the authors conclude that metals of very different characters yield spectra which are banded, or contain both distinct lines and bands—for example : magnesium, zinc, and cadmium ; copper, silver, and gold ; and others. Combustible metals giving stable and only slightly volatile oxides give banded spectra, also metals with volatile oxides, and also those metals which are not oxidised at the temperature of the flame. Certain metals give bands degraded towards the less refrangible end of the spectrum, *e.g.*, copper, silver, and gold ; aluminium and indium ; beryllium and lanthanum. Others give bands degraded on the more refrangible side, *e.g.*, magnesium, zinc, and cadmium. Elements belonging to the same group in the periodic table show in their spectra similarly constituted bands. Banded spectra are thus connected with the periodic law. E. C. C. B.

296. *Photographs of Spark Spectra.* **W. E. Adeney.** (Roy. Dublin Soc. Trans. 7. pp. 331–338, Sept., 1901.)—This paper deals with the ultra-violet spark spectra of iron, cobalt, nickel, ruthenium, rhodium, palladium, osmium, iridium, platinum, potassium chromate, potassium permanganate, and gold. A series of photographic reproductions are given of spark spectra taken in the first order with a 21·5-feet focus Rowland grating between λ4550 and λ2200. The spectra were produced by means of an Apps 10-inch spark coil with a current of 10 amperes and a condenser of 144 square feet area. In the case of the liquids platinum electrodes were used. E. C. C. B.

297. *Sensitive Paper in Röntgen Ray Work.* **M. I. Wilbert.** (Franklin Inst., Journ. 152. pp. 463–467, Dec., 1901.)—The author recommends glossy bromide paper, particularly that of the Neue Photographische Gesellschaft, Berlin. Paper has the advantage in respect of price, non-liability to breakage, storage, recording—making, say, a dozen at a time by exposing a whole packet instead of one piece—and the rapidity with which an intelligent result can be obtained, since if there be thorough rinsing in water the paper can be examined even in daylight before fixing ; and glossy bromide paper brings out details in a way the ordinary "smooth" paper does not. A. D.

298. *Chemical Reaction Produced by Radium.* **Berthelot.** (Comptes Rendus, 133. pp. 659–664, Oct. 28, 1901.)—The radiation from radium decomposes I_2O_5 and HNO_3. These are both endothermic reactions, and are caused likewise by light. On the other hand, radium radiation does not cause the separation of insoluble sulphur from a solution of the soluble variety in carbon disulphide, as light does, nor does it cause the condensation of acetylene, like the silent discharge. Furthermore, it does not accelerate the oxidation of oxalic acid in solution, like light, but it produces a peculiar discolouration in lead glass, apparently inducing the reduction of the lead and the oxidation of the manganese simultaneously. F. G. D.

299. *Chemical Effects Produced by Radium Radiation.* **H. Becquerel.** (Comptes Rendus, 133. pp. 709–712, Nov. 4, 1901.)—In view of Berthelot's recent researches (see preceding Abstract) on the chemical effects of radium radiation, the author has now published the results of experiments made some time ago. The first deals with the phenomena of colouration, observed by M. and Mme. Curie, on glass, porcelain, and paper, when exposed to radium rays. With a small tube first coloured by exposure to radiation, then deprived of its colour by heating, the author obtained a violet colouration, while a portion of the tube which had not been heated became brown in colour, gradually tending to violet during a period of six months, although the tube was kept out of the action of light. Among the phenomena which are accompanied by a giving out of heat, the first mentioned is the transformation of white phosphorus into red under the influence of radium radiation. In a similar manner, bichloride of mercury in the presence of oxalic acid is reduced by the radiation, and a precipitate of calomel is formed. The quantity precipitated varies in different experiments. Experiments made in the author's laboratory by Louis Matout on the germination of seeds of mustard and garden cresses exposed to radium rays before being planted, show an absence of germination in the seeds planted after exposure for a week or more, while of others kept under identical conditions, but not exposed to radiation, and planted at the same time, 80 per cent. germinated. Thus prolonged exposure has destroyed the faculty of germination. [See also Abstract No. 1257 (1900).] W. C. H.

300. *Induced Radio-activity and Atmospheric Air.* **H. Geitel.** (Phys. Zeitschr. 3. pp. 76–79, Nov. 15, 1901. Paper read before the 73rd Naturforscherversammlung at Hamburg.)—The author describes experiments which, with the previous ones of himself and Elster [see Abstracts Nos. 1918 and 2352 (1901)] incline him to adopt the hypothesis that atmospheric air itself possesses radio-active properties of its own. J. J. S.

301. *Phosphorescence under the Influence of Kathode Rays.* **A. Schmauss.** (Phys. Zeitschr. 3. pp. 85-87, Dec. 1, 1901.)—The capacity of various substances for phosphorescing under the action of kathode rays diminishes after a short exposure to the radiation. The cause of this fatigue was investigated by the author. The temporary fatigue which most substances exhibit is due to the heating under the influences of the kathode rays, by which the phosphorescing substances are quickly raised above the temperature of their maximum light emission, this temperature being in most cases not very high. The lasting fatigue is due in the case of some substances (such as Balmain's luminous paint and chalk) to the effect of heat. In a second group of substances (including glass) the permanent fatigue probably resembles the change of colour of the haloid salts of the alkalis, and is of a chemical nature. Thus glass can be brought back to its original state by heating it to bright redness, as under similar treatment the salts referred to regain their original colour. The temperature of maximum phosphorescence was determined for various substances. For example, the maximum in the case of Balmain's paint was found to be about 70°. J. J. S.

REFERENCE.

302. *Dispersion of Ultra-Violet Rays.* **F. F. Martens.** (Ann. d. Physik, 6. 3. pp. 603–640, Nov., 1901.)—An elaborate series of tables is given, showing the indices of refraction of various substances for different wave-lengths. J. J. S.

HEAT.

303. *Thermometers.* **W. Schloesser.** (Zeitschr. Instrumentenk. 2
pp. 281–298, Oct., 1901.)—A detailed account is given of comparative test
of thermometers of different kinds. The mean of a number of thermometer
of *verre dur* agrees very well with the air-thermometer. The errors depend
good deal upon the chemical constitution of the glass. A. D

304. *Determination of Very Low Temperatures.* **H. Pellat.** (Compte
Rendus, 133. pp. 921-924, Dec. 2, 1901.)—A gas thermometer is not availabl
for very low temperatures, because of the increasing deviation with cooling o
the properties of the contained fluid from those of a perfect gas. The genera
method proposed by Lippmann (Journ. de Phys., 2nd series, t. III. p. 277
1884) is impracticable with very low temperatures. The author proposes t
use the Peltier effect. A thermoelectric couple (preferably iron and zinc
the e.m.f. E in c.g.s. units; one of its junctions is maintained at a constan
temperature, *e.g.*, that of melting ice, while the other is carried to the tempera
ture T to be evaluated.

If Π is the Peltier effect, Kelvin's formula then gives $\Pi = T dE/dT$, o
$dT/T = dE/\Pi$. If now E and Π are known as functions of the temperature
in the forms $E = f(t)$ and $\Pi = F(t)$, then $dT/T = f(t)/F(t) = d\phi(t)/dt$, and $\phi($
is known. Then T is determined in terms of T_0 by the equation—

$$\log \frac{T}{T_0} = \phi(t) - \phi(t_0).$$

A description is then given of the apparatus employed in practice. S. H. B

305. *Emissivity of Platinum at High Temperatures in High-pressure Gase*
J. E. Petavel. (Roy. Soc., Proc. 68. pp. 246–247, June 24, 1901 (Abstract)
Roy. Soc., Phil. Trans. 197. pp. 229–254, Oct. 23, 1901.)—The rate of coolin
of a hot body in gases at high pressures was investigated in the experiment
here described, as up to the present data on this subject have not been avai
able. The experiments were carried out with a horizontal cylindrical radiato
contained in a strong steel enclosure, the enclosure being maintained at abou
18° C. by a water circulation. The method and apparatus are the same a
those described in the previous parts of the author's account of his researc
on the emissivity of platinum [see Abstract No. 1017 (1899)]. It is show
that the rate at which heat is dissipated by the radiator may be expressed b
the following formula :—

$$E = ap^{\alpha} + bp^{\beta}\theta,$$

where E = emissivity in c.g.s. units = total amount of heat dissipated
water-gramme-degrees per sq. cm. of surface of radiator per second; p =
pressure in atmospheres; θ = (temperature of radiator) — (temperature
enclosure), *i.e.*, the temperature interval in degrees Centigrade. The limi
between which the formula may be considered to hold good and the numeric

alue of the constants for the various gases studied are given in the following able :—

	$a \times 10^6$	$b \times 10^6$	α	β	The formula holds good			
					from $\theta =$	to $\theta =$	and from $p =$	to $p =$
Air	403	1·63	0·56	0·21	100	1100	7	170
Oxygen	387	1·39	0·58	0·28	100	1100	15	115
Hydrogen	2705	1·88	0·35	0·36	300	1100	7	113
Nitrous oxide	276	1·70	0·74	0·28	100	800	5	40
Carbon dioxide	207	1·50	0·82	0·33	100	1100	10	35

The emissivity in different gases at various pressures and with different temperatures of the radiator is given in a series of tables, and its variation with temperature and pressure is also expressed by means of curves. The question as to what proportion of the total loss of heat is due respectively to convection, conduction, and radiation is treated at some length in the paper. The influence of experimental conditions, such as the temperature of the gas and the dimensions of the radiator and enclosure, is also studied. All gases show a rapid increase of the effective conductivity with the pressure. In air, for instance, the rate of cooling is six times greater at 100 atmospheres than it is at atmospheric pressure. The effect of the high rate at which heat is transmitted through compressed gases is discussed, both from a theoretical and a practical point of view, and the bearing of the results on some problems of modern engineering is considered. J. J. S.

306. *Laws of Radiation at Low Temperatures.* **Compan.** (Comptes Rendus, 133. pp. 813–815, Nov. 18, 1901.)—Experiments were made on the cooling of a ball of copper, 2 cm. in diameter, blackened and of maximum emissive power, in which was plunged a junction of a copper-constantan couple, the two wires of which permitted of suspending it at the centre of a glass globe 8 cm. in diameter. A vacuum could be produced in this globe, or it could be filled with dry air at different pressures. The vacuum being first of all pushed to its extreme limit, the ball was heated without removing it from the globe, by projecting on it, by means of a lens, the positive crater of an electric arc. In this way its temperature could be made to exceed 320°. The globe was plunged in melting ice, in a mixture of solid carbonic acid and ether, or in liquid air ; the second junction of the couple being placed in the cooling agent. The author measured the rate of cooling with different ranges of temperature between 302° and —182°·5, and compared the values obtained with the formulæ of Dulong and Petit, of Stefan, and of Weber.

1. The formula of Dulong and Petit, viz., $m = v/a^{\theta}(a^t - 1)$ where $a = 1{\cdot}0077$, θ = temperature Centigrade of the enclosure, t = excess of the temperature of the cooling body over that of the enclosure, m being a constant—does not apply to the results obtained by the author, except in the interval from 0° to 200°. On taking for m the mean of the values given in this interval, the calculated velocities on either side would be higher than those observed.

2. The formula of Stefan—$m = v/T^4\theta^4$, T and θ being the absolute tempera-

tures of the body and of the enclosure, is the one which agrees best with results from the temperature of boiling liquid air up to 302°, yet from 150° 300° it would give velocities a little too high. 3. The formula of Webe $m = v/T_n^T \Theta_n^\Theta$, where $n = 1{\cdot}0042$, does not apply to low temperatures, but fr about 100° to the highest temperature observed (302°) it represents phenomenon better than the formula of Stefan. J. J.

307. *The Radiation Laws and the Determination of Temperature.* **Lummer** and **E. Pringsheim.** (Phys. Zeitschr. 3. pp. 97–100; Discussio p. 100, Dec. 1, 1901. Paper read before the 73rd Naturforscherversammlu at Hamburg.)—Referring to the investigations of the authors on dark ra ation, the question is discussed whether the radiation laws can be ma serviceable for temperature determinations. The radiation laws furnish new temperature scale, which is identical at low temperatures with the usu gas thermometer scale, but can be utilised at much higher temperatur than the method of the gas thermometer permits of. The following thr radiation laws are mentioned :—

(1) $\int_0^\infty E_\lambda d\lambda = \sigma T^4$ (Stefan-Boltzmann). (2) $\lambda_m T = A$. (3) $E_m T^{-5} =$

E_λ is the portion of the dark radiation for the absolute temperature contained between the wave-lengths λ and $\lambda + d\lambda$, whilst λ_m is the wav length for which, with this temperature, the energy E_λ in the norm spectrum has its maximum E_m; σ, A, and B are determined constants.

In the experimental corroboration of these laws the temperature w measured with the help of a Le Chatelier thermo-element which was co pared by Holborn and Day with the gas thermometer up to 1,150° C., t highest temperature which up to the present has been exactly measured wi the gas thermometer scale. By extrapolation of the empirical formulæ f the thermoelectromotive force, the comparison of the above laws can continued to over 1,400° C. This investigation may be regarded as standardisation of the thermo-element between 1,150° and 1,400° C. means of the new temperature scale founded on the radiation theory. T thermoelectromotive force is found to follow the same law which held go at lower temperatures measured by the gas thermometer. In order to forth the temperature scale above these limits, it is necessary to produce t dark radiation up to the highest possible temperature attainable in the expe ment. With this object a dark body has been devised in which a carb tube made to glow by the electric current sends out the radiation. A stopp of carbon serves as radiating surface, through which also a thermo-eleme can be led into the interior. On the outside, in order to protect the carb from combustion, the tube, as much as possible hermetically sealed, surrounded by another carbon tube electrically insulated from it. In orc to hinder the entrance of atmospheric oxygen though the radiation openi in the interior of the tube, a metal covering is laid before the opening whi is traversed by a slow stream of nitrogen. In this way it is possible carbon tubes of 1·5 to 0·75 mm. thickness of wall to glow for hours togeth without the strength of the wall being markedly diminished. In order hinder as much as possible the escape of heat to the outside, the carbon t is surrounded with many folds of a difficultly fusible substance contain air-spaces. To measure the temperature of this dark body either of the la

given above will serve. If the temperature is determined, it may be expected, hrough measurement of the distribution of energy, to gain a further proof of he law of radiation, and a more exact elucidation of the validity of Planck's quation. J. J. S.

308. *Cooling Power and Conductivity of Air.* **P. Compan.** (Comptes Rendus, 133. pp. 1202–1204, Dec. 23, 1901.)—In Dulong and Petit's formula, $p^n t^b$ for the factor of cooling due to the air (p = pressure, t = the excess of temperature, n a constant for a given substance), with a blackened copper ball of 2 cm. diameter in a flask of 16 cm., $b = 1{\cdot}232$, and $c = 0{\cdot}45$ (the same numbers as those of Dulong and Petit), so long as p is above 15 mm., but at pressures below 15 mm., both b and c increase rapidly. With the same ball in a flask of 8·3 cm., $b = 1{\cdot}154$ and $c = 0{\cdot}30$, so long as the pressure remains above 30 mm. (Desains found variations in the values of b and c.) When the speed of cooling ν becomes independent of the pressure, there are no convection currents, and the cooling is due to conductivity ($\nu = \nu_1$, say); then if ν_2 be the same so far as due to radiation, K the conductivity of air, γ the coefficient of temperature, P the weight of the ball, c the specific heat of the hot ball, e the thickness of the gas-wall, S the surface of the ball,

$$K = \frac{Pce}{tS}(\nu_1 - \nu_2).$$

From 300° to 0° the values of K correspond to a straight line which gives $K_0 = 0{\cdot}0000479$ at 0° C. and $\gamma = 0{\cdot}00130$. The value of K_0 confirms previous results; that of γ is smaller, but shows that $K_t/K_0 = \sqrt{T}/\sqrt{T_0}$, in conformity with Clausius's theory. A. D.

309. *Critical Velocity of Liquids.* **H. T. Barnes** and **E. G. Coker.** (Phys. Rev. 12. pp. 372–374, 1901.)—H. T. Barnes showed (Roy. Soc., Proc. 67, 238, 1900) [see also Abstract No. 2357 (1901)], that if water be heated while flowing through tubes at velocities less than the critical velocity, so that the motion is in the form of parallel stream-lines, then the distribution of heat is not uniform; that where the heat is applied to the outside of the tube, only a few layers of the water in direct contact with the tube will be heated, the influx water passing through the centre unheated; and that where the heat is received from a central wire, the hot water flows along the wire, leaving the sides of the tube unheated. For flows beyond the critical velocity, the flow is eddying and sinuous and the distribution of heat throughout the water-column is uniform. The authors now find that the sudden passage from direct to sinuous motion is very sharply determined by placing the bulb of a sensitive mercury thermometer in the path of the moving column of water just as it emerged from the tube; when the motion becomes sinuous, even for an instant, the mercury-column shoots up, and the break-down of the stream-line motion thus shows the attainment of the critical velocity. A. D.

310. *Expansion by Heat of Solutions of Magnesium Chloride.* **G. J. W. Bremer.** (Archives Néerlandaises, 6. pp. 455–470, 1901.)—Observations were made of the density at different temperatures of solutions of magnesium chloride of various concentrations. Expressing the relation between the density d at $t°$ and the density d_0 at 0° by the equation

$$d = d_0(1 - at - bt^2),$$

the values of the constants a and b are calculated from the observations in

various cases. The general result obtained is that the coefficient *a* increases and then diminishes, with increasing concentration. This fact leads to the conclusions that (1) the more concentrated the solution the more regular the expansion, and (2) if the expansion of two solutions of different concentration be compared, the two having equal volumes at 0°, it will be found that the more concentrated solution expands more at first, but as the temperature rises, the difference between the expansions diminishes, and finally, the less concentrated solution expands more than the other. Also, in the case of chloride of magnesium, the curves which represent the law of expansion have nearly the same point of intersection.

The results agree with Tammann's conclusion that, as regards expansion, solutions behave like water under high pressures. The solution of a substance in water has for the water the same effect as if it were subjected to a definite pressure, the value of the pressure depending on the temperature. J. J.

311. *Fusion and Crystallisation. Modification of Tammann's Theory.* **P. Duhem.** (Archives Néerlandaises, 6. pp. 93–102, 1901.)—Tammann has shown that, in the case of superfused substances, the readiness with which crystallisation takes place at first increases as the temperature falls, but reaches a maximum, and then becomes much less at lower temperatures. He has therefore suggested that at a sufficiently low temperature, the crystalline state would no longer be stable, but that the substance would pass again into the isotropic (viscous liquid) state; this temperature has been called the "second point of fusion." It is now suggested that the "second point of fusion" represents the upper limit of temperature at which the isotropic and crystalline forms can exist together in false equilibrium (like an explosive mixture of hydrogen and oxygen below the temperature of ignition), but that the crystalline, and not the isotropic, form would be the stable modification at temperatures below this point. T. M. L.

312. *Equation of State.* **J. D. van der Waals.** (Archives Néerlandaises, 4. pp. 299–313, 1901.)—In the first part of this paper the author discusses the variation with volume of the quantity *b*, which enters into his equation of state, and which is equal to four times the volume of the molecules when the volume is very great. He deduces the value—

$$b = b_\infty \left\{1 - \frac{17}{32}\frac{b_\infty}{V} + \epsilon_1\left(\frac{b_\infty}{V}\right)^2 \text{ \&c.}\right\},$$

where b_∞ is the value of b for infinitely great volume, by determining, for each sphere of distance, the mean value of the portion cut off by another sphere. Later, from the consideration of three intersecting spheres, a method of determining ϵ_1 is given, according to which its value is found to be 0·0958. An elementary deduction of the equation of state for substances with extended and complex molecules is given, which shows that only at infinite dilution is b equal to four times the volume of the molecules, and that it diminishes with the volume. In the author's opinion, the differences between Boltzmann's results and his own arise from the conception of the problem by the former as one relating to *material points*, which cannot approach nearer than a certain limit, in which case the work done by "thermic pressure" does not appear. The author prefers his own view of the problem, and the direct treatment. W. E. T.

313. *An Exact Formula for the Variation of b with the Volume.* **J. D. van der Waals.** (Archives Néerlandaises, 6. pp. 47–54, 1901.)—By a more

rigorous discussion of the equations from which the author had previously [Arch. Néerl. (2), 4. 622, 1901] deduced for a substance with triatomic molecules in which two atoms have independent motions with respect to the centre of gravity of the system, the formula—

$$(b - b_0)/(v - b) = f\{1 - (b - b_0)^2/(b_l - b_0)^2\},$$

in which f has an approximately constant value lying between 1 and 2, he now shows how to deduce an exact formula. This is effected by the introduction of a quantity m of definite signification, which expresses how much the motion of one atom contributes to the increase of volume of the molecule: m is found to lie between 1 and 2, but to be no longer a constant, and the effect of this variability is especially sensible in the value of db/dv. Preliminary calculations authorise the conclusion that for CO_2 the value of m is not very different from 5/6. W. E. T.

314. *Adiabatics of a Gas.* **G. Moreau.** (Comptes Rendus, 133. pp. 732–735, Nov. 4, 1901.)—Assuming the characteristic to be $pv = p_0v_0(1 + at + \beta t^2)$ and the isometric specific heat to be $c_0 + at$, where t denotes C. temperature, we have at once for an adiabatic—

$$v^{B-1}(1 + at + \beta t^2)\{(t - r)/(t - r')\}^A = \text{const.},$$

where r, r' are respectively $\{-a \pm \sqrt{(a^2 - 4\beta)}\}/2\beta$, and—

$$A \equiv (2\beta c_0 - aa)/a\sqrt{(a^2 - 4\beta)}, \quad B \equiv 1 + 2\beta p_0v_0/Ja,$$

being Joule's equivalent. We thus get—

$$t = (\Theta r - kr')/(\Theta - k),$$

where $\Theta^A \equiv pv^B$ and k is a parameter characterising the adiabatic; and substitution in the characteristic of this expression for t gives the pv-equation of the adiabatic. [The above expressions are unreal unless $4\beta < a^2$.] A simpler expression is also obtained by making two particular approximations; this can be valid only within a limited range. R. E. B.

315. *Characteristic for Slightly Compressible Gases.* **M. Reinganum.** Ann. d. Physik, 6. 3. pp. 532–548, and 549–558, Nov., 1901.)—The first of these two papers is an extension of an earlier one [see Abstract No. 1291 1901)], with the notation of which we have—

$$U = -Rbcv^{-1}(q - 1)\{1/(q - 4) + (c/T)/(2q - 5) + (c/T)^2/2!(3q - 6) + (c/T)^3/3!(4q - 7) + \ldots\}$$

if the attractive forces vary inversely as the qth power of the distance, where $q > 4$, giving a characteristic of the form—

$$pv = RT + v^{-1}A(T).$$

In this case the virial of the attractive forces is $-\frac{1}{2}(q - 1)U$.

In the second paper this characteristic is put into the approximately equivalent form—

$$p\{v + B(T)\} = RT,$$

and tested by application to Young's results for isopentane. The term B(T) seems to be justified, and A(T) is certainly not a *linear* function of T. R. E. B.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

316. *Rowland's Experiments on Electric Convection.* **Crémieu.** (Annal. Chim. Phys. 24. pp. 299–320, Nov., 1901.)—The negative results obtained in the two previous researches tended to throw doubt upon the existence of the electric field due to magnetic variations, and also upon the magnetic effect of electric convection. It became necessary to repeat Professor Rowland's work, eliminating certain causes of error. The result was entirely negative : Rowland's and Himstedt's deviations, when they are obtained, are not due to the magnetic field of the continuous current to which the electric convection would correspond, but are apparently traceable to purely electrostatic causes. A charged body in a field of magnetic variations is not subjected to any ponderomotive force. A rotating disk, under conditions in which one is sure that it carries with it all the electric charge communicated to it, does not produce, when this charge is varied, the effects of induction that a current would produce, transporting equal quantities of electricity and subject to variations of the same order. The same rotating disk charged in a constant manner does not produce the magnetic field of a conduction current carrying the same quantity of electricity. [See Abstracts Nos. 55 and 56 (1902).] A. D.

317. *Absence of Electric Displacement in Air moving in Magnetic Field.* **R. Blondlot.** (Comptes Rendus, 133. pp. 778–781, Nov. 11, 1901.)—The electrodynamical theories for bodies in movement, given by Hertz and Lorentz, both assert that when an insulating body is moved in a magnetic field at right angles to the lines of force, there is produced in it an electric displacement analogous to that which, according to Faraday and Maxwell, exists in the dielectric of a condenser. The two theories, however, give different values for the displacement ; that of Lorentz being equal to that of Hertz multiplied by $(K - K_0)/K$, where K is the specific inductive capacity of the dielectric in movement, and K_0 that of empty space. If air be the moving dielectric, Lorentz's value is zero, while that of Hertz is finite, and the author seeks to determine which is correct by experiment with air as the dielectric in motion. The invariable result of every experiment was to confirm the theory of Lorentz, as no displacement could be observed. W. C. H.

318. *Absence of Action of a Magnetic Field on a Mass of Air which is the Seat of a Displacement Current.* **R. Blondlot.** (Comptes Rendus, 133. pp. 848–850, Nov. 25, 1901.)—This paper deals with a correlative problem to that treated in the preceding Abstract. The author sets himself to find if, when a displacement current is set up in a body of air in a magnetic field at right angles to the lines of force, any action upon the air will be produced by the magnetic field. He arrives at the conclusion that there is no such action. Following the principle of equality of action and reaction, one might therefore conclude that a displacement current in air exercises no magnetic action, and that, in consequence, the charging current of a condenser is, from the magnetic point of view, an open current. This, however, would be the

negation of one of the principles on which Maxwell's theory is based; and if we desire to retain the theory, we must renounce the principle of reaction. Poincaré has already shown some incompatibilities between the principle of reaction and several of the electrodynamical theories, and, following him, the author does not see in this fact any reason to renounce beforehand those theories whose fruitfulness has been shown by the great discoveries to which they have led. W. C. H.

319. *Contact-Electricity and Surface-Tension.* **H. Pflaum.** (Phys. Zeitschr. 2. pp. 750–754, 1901. Journ. der Russ. Phys. Chem. Gesell. u. Nachr. des Technolog. Instituts.)—Electrisation is in all cases traceable in the last resort to the contact of dissimilar surfaces. Before contact, the two substances each present a condition of equilibrium between the ether of their inner volume and the surrounding ether; these conditions are disturbed upon contact, the conditions of the respective substances being approximated to one another. The condition of the ether within a substance is indicated by the refractive index; and (Coehn) bodies with high limiting values of the refractive index (small velocities of propagation of ether-waves) become positive upon contact with bodies of lower refractive indices. The condition of the ether within a substance is also indicated by the surface-tension; bodies with higher dielectric constants have also higher coefficients of capillarity. Liquids with higher coefficients of capillarity have also higher specific cohesions at the boiling-point and higher latent heats of their vapours. Obach found a relation between dielectric constants and latent heats on boiling. As a rule the greater the dielectric constant, the less the coefficient of thermal expansion. The dielectric and the capillary constant vary with temperature according to the same law. With solids the same association is indicated. Polished glass has a higher superficial tension than matt glass; and the former becomes positive, the latter negative on rubbing with leather or wool. Cork pressed upon metal or guttapercha so that it cannot dilate laterally has its superficial tension raised and becomes positively charged; if it be rubbed on, it is free to expand, and being warmed more than the metal, its superficial tension falls in proportion more than that of the metal, and the cork becomes negatively charged. Differences may thus be occasioned between the effects of gentle rubbing and of hard rubbing. Hesehus found a relation between the residual charge of a body and the expansion by heat, and traced the former to the mutual action between the interior condition and that of the surrounding ether. There is a complete parallelism between the variations of the dielectric constant and those of the superficial tension in various mixtures of ether ($C_2H_{10}O$) and chloroform, and also of alcohol and water, irregular though these variations be. A. D.

DISCHARGE AND OSCILLATIONS.

320. *Action of Magnetised Electrodes upon Electrical Discharge Phenomena in Rarefied Gases.* **C. E. S. Phillips.** (Roy. Soc., Phil. Trans. 197. pp. 135–150, Sept. 3, 1901. Abstract in Roy. Soc., Proc. 68. pp. 147–149, May 4, 1901.)—In the present paper the author describes further experiments illustrative of the effects produced by a magnetic field upon the distribution of ions within a highly evacuated space [see Abstracts Nos. 683 (1899) and 853 (1900)], and deals more particularly with the conditions necessary for the production of a luminous ring in rarefied gases and under the influence of electrostatic and

magnetic forces. The cause of the luminous phenomenon is traced to the action of the magnetic field upon electrified gaseous particles within the rarefied space, and it is shown by experiment that the rate of change of the magnetic lines is an important factor. The ring itself is invariably negatively electrified, and its direction of rotation is that of the current induced in a loop of wire when the loop is suddenly moved up to a north magnetic pole—clockwise, looking through the loop at the pole. The outside of the glass bulb is always negatively electrified when the luminous ring appears in the interior, thus indicating the removal of a layer of positively electrified gas from the inner surface of the bulb by the action of the magnetic field. It is established by experiments that the loss of positive electrification from charged bodies in the rarefied gas is caused by the magnet, through the concentration of negative ions which occurs at the strongest part of the magnetic field immediately the electrodes are magnetised, and also that the luminosity of the ring itself is due largely to the collisions between the incoming streams of positive ions and this accumulation of negatively charged gas between the pointed ends of the electrodes. The direction of rotation of the ring forms a difficulty on the assumption that a rapidly moving ion is equivalent to a current along a flexible conductor, but the author accounts for it in the following manner: When the potential difference between the accumulation of negative ions at the centre of the bulb and the layer of electrified gas upon the inner surface of the glass is such that a shower of incoming positive ions occurs, and the luminous ring appears, the outer portion of the ring will be more positive than the surrounding negatively electrified cloud of gaseous particles. These will, therefore, be attracted inwards, and in that way give a rotatory motion to the luminous gas-mass in the direction actually observed. W. C. H.

321. *Electric Conductivity of Flames and Gases.* **A. de Hemptinne.** (Zeitschr. Phys. Chem. 39. pp. 345–352, Dec. 13, 1901.)—In determining the conductivity of gaseous mixtures at the moment of explosion, the author now uses an apparatus comprising two glass tubes, joined to a **T**, and a galvanometer, instead of the capillary electrometer previously employed. The galvanometer is found to be noticeably deflected in mixtures of H and O when the conditions favour the condensation of water vapour, *i.e.*, when air and dust can enter; the effect is much weaker when the apparatus communicates with a vacuum, and when the experiments are made at temperatures above 100° C. Hardly any deflection is observed in mixtures of H and Cl, and of CO and O. The author regards explosions as instantaneous flames. H. B.

322. *Discharge Potential of Hydrogen at Mercury Kathodes.* **A. Coehn** and **E. Neumann.** (Zeitschr. Phys. Chem. 39. pp. 353–354, Dec. 13, 1901.)—The electrolytic generation of hydrogen is strictly reversible only with kathodes of platinised platinum, whilst with other metals a supertension is required (Caspari), which Ostwald has ascribed to the condition of the metallic surface. That condition should, however, only influence the formation of bubbles, not the discharge of hydrogen ions. Yet Dannenberg, waiting, like Caspari, not for the appearance of bubbles, but for the flow of a steady current, observed a high discharge potential with mercury kathodes, indicating that the nature of the metal, and not only its surface condition, is of influence. The authors dissolve concentrated HCl in alcohol

and find that the difference in the discharge potentials of hydrogen between platinum and mercury kathodes is substantially the same at — 85° C. (mercury frozen) as at + 18° C. H. B.

323. *Geissler Tubes in a Magnetic Field.* **H. Pellat.** (Comptes Rendus, 133, pp. 1200–1202, Dec. 23, 1901.)—When a long tube is laid through a magnetic field, at right angles to it; when the field is set up, not only is the anode light driven towards the strongest part of the field, but the stratifications seem to collect into the same region, new ones being formed at the anode, not at the kathode, the stratifications round which remain nearly undisturbed. The stratifications also become inclined to the axis of the tube in the field; they rise from the left hand to the right hand of an observer in the tube, looking down the field (towards the south pole), the plane of each stratification having rotated round the direction of the field. These phenomena of crowding and slanting occur in uniform or non-uniform, constant or variable fields; best with fields of from 90 to 170 c.g.s. units. If the tube be put through the holes in pole-pieces made use of in rotatory polarisation, when there is no field the tube is, between the pole-pieces, filled with the anode light; but when a field of from 2,500 to 3,000 c.g.s. units is set up the anode light shrinks to about one-third of its diameter, remaining axial. This is not easy to explain; the field is about 3 per cent. stronger along the axis between the holes than opposite the margins of the holes; and this would explain a concentration of magnetic oxygen molecules along the axis of the tube, but would not explain the similar behaviour of diamagnetic hydrogen. Does hydrogen become magnetic in a Geissler tube? A. D.

324. *Velocities of Ions in Gases.* **K. v. Wesendonck.** (Phys. Zeitschr. 3. pp. 45–46, Nov. 1, 1901.)—It is known that ozonised oxygen is a relatively bad conductor, especially if its conducting power is measured by allowing negative electricity to leak away through it. This, according to the author, is the cause why the ratio of the velocities of the ions is the same in air as in nitrogen, when the ions are produced by Röntgen rays or ultra-violet light, but is different if they are produced by a point discharge, the latter process producing ozone. R. S. W.

325. *Electrical Conductivity of Air and Salt Vapours.* **H. A. Wilson.** (Roy. Soc., Proc. 68. pp. 228–230, May 23, 1901 (Abstract); Roy. Soc., Phil. Trans. 197. pp. 415–441, Nov. 22, 1901.)—The object of the experiments described was to obtain information on the variation of the conductivity of air and of salt vapours with change of temperature, and on the maximum current which a definite amount of salt in the form of vapour can carry. The method employed was the following: A current of air containing a small amount of a salt solution in suspension in the form of spray was passed through a platinum tube heated in a gas furnace; this tube served as one electrode, and the other was fixed along its axis. The temperature of the tube was measured by means of a platinum platinum-rhodium thermo-couple, and the amount of salt passing through the tube was estimated by collecting the spray in a glass-wool plug. From the temperature variation of the conductivity the energy required to produce the ionisation can be calculated, and this compared with the energy required to ionise bodies in solutions. After a detailed description of the apparatus used, the results of observations on the variation of the current with the e.m.f., and the variation with the temperature of the current through air and through salt vapours are given.

The relation between the current and e.m.f. in air was found to depend very much on the direction of the current. When the outer electrode was negative the current attained a saturation value with an e.m.f. of about 200 volts, but when the outer tube was positive it increased rapidly with the current even with an e.m.f. of 800 volts.

With salt vapours the relation between the current and e.m.f. was not much affected by reversing the current. The current was always greater when the outer tube was negative, the reverse being the case with air alone. At low temperatures the current attained a saturation value, but above 1,000° C. it was found to increase more nearly proportionally to the e.m.f. The variation of the current at constant e.m.f. with the temperature for air was found to be approximately capable of being represented by a formula of the type $C = A\theta^n$, where C is the current, θ the absolute temperature, and A and n constants. The constant n depends on the e.m.f. used. With 240 volts it was 17, and with 40 volts 13. The current, therefore, does not begin suddenly when the temperature is raised, but always increases regularly with the temperature.

The energy required to ionise 1 gramme molecular weight of air was estimated by supposing that the fraction of the gas dissociated into ions is proportional to the current at small e.m.f.'s By means of the ordinary thermo-dynamical formula giving the variation of the dissociation with the temperature, the energy in question can then be obtained. The result for air is 60,000 calories between 1,000° and 1,300° C. This amount of energy is of the same order of magnitude as the energy set free when H and OH ions combine to form water in a solution. The current through a halogen salt vapour in presence of air and water reaches a maximum value near 900°, and then falls as the temperature rises. Near 1,100° it again rises rapidly with the temperature.

The energy required to ionise 1 gramme molecular weight of KI was found to be about 15,000 calories at about 300°. The maximum current carried by a definite amount of salt vapour was found to be nearly equal to the current required to electrolyse the same amount of salt in an aqueous solution.

These experiments were made with salts of potassium. Later experiments were carried out with various salts of the other alkali metals, and an account is given of these in an appendix to the paper. It was found that with many salts, on first applying the p.d., the current was often abnormally great for a short time and then settled down rapidly to a steady value, just as it does for air. The saturation current was found to be inversely proportional to the electrochemical equivalent of the salt. It appears from the experiments that Faraday's laws for the passage of electricity through liquids apply also to alkali salts in the state of vapour. This result supports the theory that the passage of electricity through salt vapours is a process very analogous to the electrolysis of salt solutions. J. J. S.

326. *Electric Vibrations.* **D. Mazzotto.** (N. Cimento, 2. pp. 173–187, Sept., 1901.)—A controversial paper in reply to M. Lamotte (Wied. Annal. 65. p. 92, 1898.)—The author maintains that his methods are exact and are confirmed by Lamotte's own results. [See Abstracts Nos. 170 (1898) and 67 (1902).] A. D.

327. *Theory of Hertzian Oscillators.* **H. Poincaré.** (Écl. Électr. 29. pp. 305–307, Nov. 30, 1901.)—A paper by K. R. Johnson [see Abstract

No. 1927 (1901)] criticised by the author. The experiments of Décombe and Tissot, showing that the spark discharge can be analysed by a turning mirror, are totally at variance with his theory of the exciter. Still greater exception is taken to his theory of the resonator, for according to the calculations of Johnson the resonator responds equally well whatever the mutual induction of the sender and receiver, *i.e.*, whatever the distance between them. The author considers that Johnson's results are obtained partly because he fails to take account of displacement currents. P. E. S.

328. *Loaded Conductors.* **M. I. Pupin.** (Elect. World and Engineer, 38. pp. 587–588, Oct. 12, 1901.)—This is a note upon the author's original paper on the behaviour of loaded conductors or circuits when used for telephonic transmission [see Abstract No. 1381 (1899)]. Numerical cases are taken, and the results exhibited graphically as regards attenuation constants and wave-lengths, as the number of loads per wave-length is changed through a considerable range. It is thus shown that loaded conductors act, to a close approximation, like their corresponding uniform conductors, when the number of loads is sixteen per wave-length. When, on the other hand, the number of loads per wave-length is reduced to four, the resemblance between the two conductors is very slight. The attenuation constant is very high for only four loads per wave-length, and may be anything if the number of loads is reduced to between 4 and π. Also the wave-lengths of the loaded conductor is a definite quantity only as long as the conductor is properly loaded. On a poorly loaded conductor the wave-length may be either smaller or greater than the wave-length on the corresponding uniform conductor. E. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

329. *Electric Conductivity of Red Nitric Oxide Vapours.* **A. Pochettino.** (Accad. Lincei, Atti, 10. pp. 202–207, Nov. 3, 1901.)—Hempel found (1866) that red N_2O_4 vapours interposed in the path of the spark of a frictional machine released all tension, so that no spark passed. These vapours are at ordinary temperatures partly dissociated into NO_2. Other observers have found that N_2O_4 vapours have not a high conductivity at any temperature (J. J. Thomson, de Hemptinne); the conductivity as deduced from the resistance to dispersion of charge is about the same as that of ordinary air. The author finds that the sparking distance is less in these vapours than it is in air, and for a discharge between a point and a plane the vapours are a better insulator than air. The effect observed by Hempel must be due to some secondary cause. A. D.

330. *Electric Properties of Copper-Cobalt Alloys.* **G. Reichardt.** (Ann. d. Physik, 6. 4. pp. 832–855, Dec., 1901.)—Experiments conducted in the Reichsanstalt on alloys supplied by Basse and Selve in rods 2 cm. in diameter. Alloys with up to 40 per cent. of Co can be cut with the circular saw and drawn out to wire; richer cobalt alloys could only be cut on a planing machine. The analyses were made by Funk and Dietz; the alloys contained traces of Fe and Ni (the Co was not quite free from Cu), and were not very homogeneous. The resistance of the wires decreases on continued heating for 48 hours up to 160° C.; this applies also to manganin and to the Kulmiz resistances, not to constantan. The specific resistance increases

with the proportion of Co, very rapidly for alloys containing either little or very much cobalt. The temperature coefficient is a linear function of the temperature. In two alloys with more than 3 per cent. of Co the temperature coefficient and resistance rise simultaneously, contrary to most other alloys. The thermoelectric force increases first up to 3 per cent. of Co, then sinks, and rises again above 90 per cent. of Co. Thus slight admixtures of either metal to the other have a very marked effect throughout; as regards the medium percentages, the ascending and descending curves (starting from Co or Cu respectively) do not coincide. The effect of cobalt in copper alloys is about as strong as that of manganese, and three times as strong as that of nickel, from which cobalt differs in electric and magnetic, as in many other properties; the cobalt-copper alloys remain magnetisable up to red glow, the nickel-copper alloys are not magnetic. Only the alloys containing 1 or 2 per cent. of Co appear to be of practical value as thermo-couples. H. B.

331. *Measurement of Self-Inductance.* **W. Duane.** (Phys. Rev. 13. pp. 250–252, Oct., 1901.)—If a coil is wound in two parts, with mutual induction M and self-inductances L_1 and L_2, the self-inductance of the whole is $L' = L_1 + 2M + L_2$ when the current flows in the same direction, and $L'' = L_1 - 2M + L_2$ when it flows in opposite directions, through both coils in series. The ratio $L'/L'' = A$ is found by comparing each with a third self-inductance L. Then M is measured by any usual method (*e.g.*, the earth-inductor and ballistic galvanometer, &c.). Then $L' = 4MA/(A-1)$ and $L'' = 4M/(A-1)$. If the coil be not so wound, the above method can be applied by conjoining another coil with it, maintaining a uniform distance between them, so as to keep the value of M constant. A. D.

332. *Wire Bridges for Elementary Students.* **J. Pernet.** (Archives Néerlandaises, 6. pp. 377–381, 1901.)—The author begins by recommending the use of simple apparatus in which the corrections to be applied and the degree of accuracy attainable can be arrived at. Not only for cheapness but also as having great instructional value is this advisable. Illustrations of the types of experiment to be chosen and to be avoided are drawn from thermometer calibration and from the wire bridge calibration methods of Strouhal and Barus, and Thiesen. A form of wire bridge illustrative of the previous argument is then described. The wire (whose material has as small a temperature coefficient as possible) is 510 cm. long. It is arranged in straight pieces and spirals on a board 2 metres long as follows:—10 cm. straight, 90 spiral, 10 straight, 90 spiral, 110 straight, 90 spiral, 10 straight, 90 spiral, 10 straight. The central piece, 110 cm. long, is the part where the measurements are taken, and it is accordingly provided with a subdivided scale. J. W. P.

333. *Wehnelt Interrupter.* **M. A. Codd.** (Elect. Rev. 49. pp. 787–789, Nov. 15, 1901.)—The paper describes several experiments made with the Wehnelt interrupter. As the voltage on the primary coil is increased the current and the spark-length increase up to a maximum and then diminish, but if two breaks be used in series they increase continually within the limits of voltage employed (0 to 200 volts). With two breaks the spark-length is considerably greater than with one. The length of spark, and the effect of using two breaks in series, depends upon the self-induction of the primary coil; the best value of the self-induction depends on the current, the frequency, and the voltage. Any number of breaks can be worked in parallel, provided the surface of platinum exposed in each break be the

same, and the strength of acid the same. The author found the break to cease working at a temperature of 75° C., but if kept cool by a water-jacket, it continued to work well for an indefinite time. He describes and gives an illustration of a form of break found satisfactory in use. G. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

334. *Action of Direct-current Armatures on Alternating Currents.* **M. Latour.** (Écl. Électr. 29. pp. 294–300, Nov. 23, 1901.)—The author gives a theory of the properties which he has discovered of direct-current armatures when traversed by alternating currents. These properties were called in question by Leblanc [see Abstract No. 80 (1902)], who, from *à priori* considerations, gave reasons for doubting them. The author quotes a letter from Boucherot, who states that he has experimentally proved that the impedance between two neighbouring brushes pressing on the commutator, when connected to a polyphase system, is a function of the speed of the armature. He took the drum-wound armature of a four-pole direct-current dynamo and placed it in the stator field of an induction motor, the windings of the stator being left open-circuited. With direct-currents the resistance between No. 1 and No. 3 brush, or between No. 2 and No. 4 brush, was 1·8 ohms. The brushes were then connected to a two-phase system of frequency 25. The impedance between the brushes was found to vary from 15 ohms at rest to about 2 ohms at synchronism, and at higher speeds it increased. At speeds greater than synchronism the armature acted like a condenser. If the armature were rotated the other way, the impedance continually increased as the speed increased. He also proved experimentally that the impedance did not vary at all as the speed altered, if only single-phase alternating currents were used. Latour gives a complete theoretical discussion of this property, and mentions several practical uses that can be made of his discovery, as *e.g.*, constructing self-exciting polyphasers, &c., most of which are mentioned in his patent applied for on Dec. 13, 1900. A. R.

335. *Properties of Direct-current Armatures Traversed by Alternating Currents.* **A. Heyland.** (Écl. Électr. 29. pp. 328–329, Nov. 30, 1901.)—Leblanc in his paper [see Abstract No. 80 (1902)], disputing the alleged properties of direct-current armatures traversed by alternating currents, attributes the statement of them to the author. Heyland points out that in his motor [see Abstract No. 2475 (1901)] the commutator bars are all connected together by non-inductive coils of appreciable resistance. He agrees in general with Leblanc's conclusions. A. R.

336. *Rectifier.* **F. J. Koch, Jr.** (Elektrotechn. Zeitschr. 22. pp. 853–854, Oct. 10, 1901.)—When a rectified current is used to charge a battery, current passes into the battery only so long as the e.m.f. of the rectified current is greater than that of the battery, and consequently in each current impulse (corresponding to each half cycle in the alternating current) there is a period during which the battery receives no charge, and two points where the opposing e.m.f.'s are equal and the current is zero. The author, in his device, breaks the circuit at one of these points and closes it again at another. This he does by a polarised relay with two opposing shunt windings, one taking the alternate pressure and the other the battery pressure; the relay is

arranged so as to close the circuit only when the alternate pressure is of the same sign as and greater than the battery pressure. The self-induction of the relay windings and the armature inertia, however, have the effect of retarding the moments of opening and closing, and the author to remedy this includes in series a condenser and a coil with adjustable iron core, by which the phase of the current in the relay windings can be regulated so that the circuit is opened at the proper moment. If the battery pressure be nearly equal to the maximum alternate-current pressure, the period between closing and opening the circuit will be far shorter than that between opening and closing, and too short for proper working. On this account the author inserts a choking coil in the main circuit, which has the effect of spreading out the current curve, making the time of closed circuit longer. A small apparatus for rectifying 20 amperes at 120 volts and 50 ∿ was constructed, and worked quite sparklessly. G. H. B.

337. *Permeameter.* **F. G. Baily.** (Electrician, 48. pp. 172–174, Nov. 22, 1901. Paper read before the British Association at Glasgow.)—This permeameter is designed to read the permeability directly, without measurement of B or H. The apparatus consists of two long magnetising coils side by side, in which two strips of the specimen are placed. The magnetic circuit is completed by two short blocks of soft iron at the ends, provided with clamps. One of the blocks is divided across the direction of the lines of force, and a gap is made by the insertion of a thin brass sheet. Above this gap is pivoted on a needle-point a system of two vertical magnets with reversed poles, forming an astatic combination. The lower pair of poles lies close to the iron pole-pieces, and is affected by the leakage magnetic field; the force acting on it is therefore proportional to the induction in the circuit. Round the upper pair of poles is a coil which carries the magnetising current. The needle system has a pointer capable of a small motion between two stops; in its zero position the magnet poles lie in the plane of the air-gap. The coil round the upper poles can be moved about a vertical axis, so as to vary the force exerted in the poles from zero to a maximum. Its position is read on a scale. This coil is moved till the needle system comes to zero, when there is a definite relation, depending on the constants of the apparatus, between the magnetising current and the induction. The scale can be given an empirical graduation to read μ directly. The author points out the sources of error in the apparatus, which are in general negligible. G. H. B.

338. *Measurement of Magnetic Field Strength by the Quadrant Electrometer, and the Susceptibility of Water.* **J. Koenigsberger.** (Ann. d. Physik, 6. 3. pp. 506–519, Nov., 1901.)—The author first shows that the change of field strength through a coil is proportional to the time-integral of the pressure in an open circuit as well as to that of the current in a closed circuit, and consequently that an electrostatic voltmeter is equally well adapted for measurements of field strength as is the ballistic galvanometer. The quantities which must be determined for the measurement are the constant, the period and the logarithmic decrement of the electrometer, and the number of turns and area of the induction coil. The advantage of the electrometer over the ballistic galvanometer are its freedom from magnetic disturbances, and the greater accuracy with which its constant can be determined in absolute units by use of a standard cell, than can that of a galvanometer by measurement of current and resistance, or of horizontal intensity. Further, in the case of a d'Arsonval galvanometer, its high damping precludes an accurate determination of the

period. The electrometer employed was that designed by Himstedt (Wied. Ann. 50. p. 753, 1893), the needle being charged by 100 Cu-Zn cells in magnesium sulphate. Its constant was 0·004 volt per mm. at 2,300 mm. scale-distance. All the constants mentioned above could be determined with an accuracy of ½ in 1,000, while readings showed a probable error of 1 in 1,000, due probably to variation in the magnetising current.

The author then measured the susceptibilities of iron chloride solution and of water by Quincke's method. The different values obtained by other experimenters he attributes to errors in the measurement of the field strength, which he believes to be greatly reduced by the use of the electrometer. He found the susceptibility of water, compared with that of air, to be at 22° C. $0{\cdot}804 \times 10^{-6}$, and compared with vacuum, $0{\cdot}781 \times 10^{-6}$. That of iron chloride solution, compared with vacuum, was, at 18° C. $\{87{\cdot}9\,.\,p - 0{\cdot}781\,(1-p)\}\,10^{-6}$, where p is the percentage of iron chloride. G. H. B.

339. *The Law of Magnetic Induction.* **E. Müllendorff.** (Elektrotechn. Zeitschr. 22. pp. 925–928, Nov. 7, 1901.)—It is shown that a formula connecting magnetising power and magnetic induction can be obtained. This takes the form—

$$B = a\left(1 - \frac{1}{\sqrt{1 + bM^2}}\right) + cM,$$

where B = number of lines per sq. cm., M = magnetising power in ampere-turns per cm., and a, b, c are constants depending on the material. These are given for the two cases below :—

	a	b	c
Wrought iron	16,870	0·1	3·2
Cast iron	6,500	0·3	25

The agreement between the observed and calculated values is fairly close. W. W. H. G.

340. *Variations of Terrestrial Magnetism.* **W. van Bemmelen.** (Archives Néerlandaises, 6. pp. 382–384, 1901.)—A new series of fluctuations in the horizontal component of the earth's magnetism is here pointed out. The observations are taken at Batavia, and compare with similar ones at Zi-Ka-Wei and at Karang-Sago. The amplitude is only of the order of 10^{-4} of the horizontal component, and the period a few minutes. The duration of this pulsation varies from several minutes to several hours. The observations are admitted to be still insufficient ; but an explanation is suggested in the electric currents which, according to Schmidt, are circulating round the globe in the atmosphere and causing the polar auroræ. Periodic fluctuations in these currents are suggested as the cause of the magnetic pulsations here observed. J. W. P.

REFERENCES.

341. *Application of Grassmann's "Ausdehnungslehre" to Alternating-Current Problems.* **F. Punga.** (Zeitschr. Elektrotechn., Wien, 19. pp. 505–508, Oct. 20, and pp. 516–520, Oct. 27, 1901.)—The author gives an account of the topographic method of solving alternating-current problems, deducing it from Grassmann's *Ausdehnungslehre.* A. H.

342. *Application of Lagrange's Equations to Electrodynamics.* **E. Carvallo.** (Comptes Rendus, 133. pp. 924–927, Dec. 2, 1901.)

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

343. *Deliquescent and Hygroscopic Salts of Copper, Cobalt, and Nickel.* **W. N. Hartley.** (Roy. Dublin Soc., Trans. 7. pp. 313–320, July, 1901.)—The experiments described were made with the object of ascertaining the conditions of equilibrium under ordinary atmospheric changes, which govern the formation of hydrates of the hygroscopic and deliquescent haloid salts of copper, cobalt, and nickel. The observations appear to confirm the conclusions drawn by the author from his previous experiments [see Abstract No. 161 (1901)], and show that the bromides are more deliquescent than chlorides, and the iodide than the bromides; also that the most stable liquid hydrates are those of nickel iodide, with 23 and 21 molecules of water, while next in order are the cobalt bromide and nickel bromide, with 18 molecules; cobalt chloride, with 11 molecules; cupric bromide with 4 molecules; and cupric chloride with 3 molecules of water. The chemical relationship of the absorbed water to the salt is shown by the fact that the three metals do not differ largely in atomic mass, the differences in the molecular mass of each of the salts being principally due to the atomic masses of the halogen elements, which differ widely. It appears that it is not any one constituent of the salt, but the salt molecule as a whole which combines with the water, and that the attraction of the salt for water is independent of the molecular mass of the salt. That is, it is a true chemical combination, dependent for its formation on the chemical property of the whole molecule of the salt, and not upon that of any one or other of its constituents. These results have a practical bearing on the preparation of the crystallised compounds, the conditions under which they may be produced being now known. J. J. S.

344. *Pressure as the Supplement of Temperature in Ignition Phenomena.* **W. Spring.** (Archives Néerlandaises, 6. pp. 257–261, 1901.)—On slowly compressing a mixture of cuprous oxide and sulphur the following reaction takes place *explosively*:—

$$2Cu_2O + 3S = 2Cu_2S + SO_2 :$$

Thus in this case pressure has had a similar effect to temperature in increasing the speed of an exothermic reaction. [See also Abstract No. 769 (1901).]
F. G. D.

345. *Vapour-Tensions of Binary and Ternary Mixtures of Liquids.* **F. A. H. Schreinemakers.** (Archives Néerlandaises, 4. pp. 346–369, 1901.)—This paper opens with an account of the author's previous experimental and theoretical work on the systems water-phenol; water-aniline; water-phenol-aniline [see Abstract No. 532 (1901)]. This is followed by a description and sketch of the apparatus employed in determining the vapour pressures and and phase-compositions of polyphase liquid systems, and a full theoretical discussion of the data obtained for the three systems already mentioned.
F. G. D.

346. *Phase-law Study of Phosphonium Chloride.* **G. Tammann.** (Archives Néerlandaises, 6. pp. 244–256, 1901.)—Measurements giving the *p-t* curves for

the following systems: crystals, vapour; crystals, liquid; liquid vapour. The volume-changes on melting and the corresponding heats were also measured. The liquid-vapour system was followed up to the critical point. A peculiarity of the system solid-liquid in this case is that the corresponding *p-t* curve extends into the *hypercritical region, i.e.*, the solid and liquid can coexist at high pressures at temperatures lying far above the critical point of the system liquid-vapour. F. G. D.

347. *Remarks on a paper of Schükarew's.* **J. J. van Laar.** (Zeitschr. Phys. Chem. 39. pp. 342–344, Dec. 13, 1901.)—In a recent paper [see Abstract No. 114, 1902] Schükarew had deduced thermodynamically a new law of partition between two phases. In the present note van Laar points out that Schükarew's reasoning is entirely fallacious. F. G. D.

348. *Catalysis in Concentrated Solutions.* **J. M. Crafts.** (Chem. News, 84. pp. 205–207, Oct. 25, and pp. 213–215, Nov. 1, 1901. From the Amer. Chem. Soc., Journ. 23, No. 4.)—The hydrolysis of 1:3:4 metaxylene-sulphonic acid by means of hydrochloric or sulphuric acid proceeds at 100° with a velocity which is convenient for measurement; nitric acid, however, has hardly any hydrolysing action, and was not further studied. In the case of catalytic actions, such as the inversion of sugar, which proceed in dilute solution, the acid used becomes proportionately less active as its concentration increases, and the effect produced is usually regarded as due to the hydrogen ions. In the hydrolysis of metaxylene-sulphonic acid, however, a 38 per cent. hydrochloric acid acts with thirty-five times greater rapidity than a 19 per cent. acid, and the velocity is further increased more than threefold by the addition of half its weight of zinc chloride to the 38 per cent. acid. In explanation of this difference it is pointed out that the sugars and esters which have previously been investigated are not themselves capable of any marked degree of dissociation, whilst the sulphonic acids are dissociated to nearly the same degree as the strongest acids; if hydrolysis takes place only upon undissociated molecules, the remarkable increase of velocity due to the use of concentrated acids and to the addition of zinc chloride may be owing to the prevention of the dissociation of the catalysed acid, whilst that of the catalysor subsists to a certain degree. In two preliminary experiments evidence was obtained that the sulphonic acids are capable to some extent of bringing about their own hydrolysis. Further experiments are in progress. T. M. L.

349. *Crystallography of the Double Selenates, $R_2Mg(SeO_4)_2, 6H_2O$.* **A. E. Tutton.** (Roy. Soc., Phil. Trans. 197. pp. 255–284, Oct. 26, 1901.)—The author gives the results of an examination of the magnesium double selenates of the above composition, R representing K, Rb or Cs. Comparison is made with the results obtained for the corresponding zinc double selenates previously examined [see Abstract No. 170 (1901)]. T. H. P.

350. *Polymerisation of Inorganic Chloro-anhydrides.* **G. Ciamician.** (Accad. Lincei, Atti, 10. pp. 221–226, Nov. 17, 1901.)—The fact that the molecular weights obtained by the ebullioscopic method for certain inorganic chloro-anhydrides seem to indicate polymerisation of these compounds, has been explained by Oddo as due to the volatility of the dissolved substances at the temperature of the boiling solution. On determining the value of the ratio a of the concentrations of phosphorus oxychloride in the vapour

given off from a benzene solution, and in the solution itself, and allowing for the volatilisation by multiplying the observed molecular weight by $(1-\alpha)$, Oddo found that the numbers obtained were still greater than the true molecular weight. On repeating these experiments, however, the author finds for α a mean value of 0·515, Oddo's numbers being 0·27, 0·31 and 0·27; correcting by means of the value 0·515, the experimental molecular weights agree well with the normal value. T. H. P.

351. *Law of Action of Invertin.* **V. Henri.** (Zeitschr. Phys. Chem. 39. pp. 194–216, Dec. 5, 1901.)—The author has made an extensive series of experiments on the velocity of inversion of cane-sugar by invertin. Instead of the equation $\frac{dx}{dt} = k(a-x)$, he proposes the equation—

$$\frac{dx}{dt} = k_1\left(i + \varepsilon\frac{x}{a}\right)(a-x),$$

to express the velocity, where x = amt. of invert sugar produced at any moment, a = original amt. of cane-sugar, k_1, ε = constants. Experience shows that in the present case ε has very nearly the value unity. The integrated expression, when $\varepsilon = 1$, is $2k_1 = \frac{1}{t}\log\frac{a+x}{a-x}$. This agrees fairly well with the experimental results. The *duration* of the action has no influence on the activity of the diastase, *i.e.*, the velocity at any moment is only determined by x and a. The "constant" k_1 varies with a, diminishing as a increases, but $k_1 a$ is not constant (as Duclaux assumed). F. G. D.

352. *Determination of Molecular Weights of Substances in Dilute Solutions.* **G. Guglielmo.** (Accad. Lincei, Atti, 10. pp. 232–239, Nov. 17, 1901.)—All those methods used in hygrometry to determine the tension of the aqueous vapour of the air and the relation between this tension and that of saturated vapour at the same temperature, can be employed to measure the tensions of vapours in contact with (1) a solution, and (2) the pure solvent, from which the molecular weight of the dissolved substance can be deduced. The author describes three different methods of working, in all of which only very simple apparatus is required. In the first method, a layer about 1 cm. deep of the solution is placed in a small flask furnished with a three-holed stopper through which pass two thermometers reaching to within 1 cm. of the liquid, the bulb of one being surrounded by two or three thicknesses of filter paper fastened to the thermometer; through the third hole passes a glass rod with its lower end bent horizontal for the purpose of stirring the liquid. The measurement is made by raising the stopper for a moment, and by means of a pipette, thoroughly moistening the covered thermometer bulb with the solvent; the stopper being replaced, the temperatures of the two thermometers soon become constant and are read off. Then $M = Cp/(t - t_1)$, C having the value $BF/(A/H + h)$, where M is the molecular weight of the dissolved substance, p the weight of the latter per 100 parts of the solvent, t and t_1 the temperatures of the uncovered and covered thermometer bulbs, F the vapour pressure of the solvent at $t°$, H the atmospheric pressure, h the variation of the latter for 1°, and A, B, and C constants. The value of C may be calculated from the expression given above, or it may be determined experimentally by means of a solution of a compound of known molecular weight. In the second method no thermometer is needed, the rate of evaporation, and hence the rate of cooling, of a rod or tube surrounded

at its lower part by filter paper and moistened with the solvent being measured by its loss in weight in a certain time when placed in the flask employed in the previous method. The last method also makes use of a wide-necked flask fitted with a perforated stopper which carries a wide nickeled tube closed at the bottom and containing a little of the solvent; the top of this tube is closed by a trebly-bored stopper through which pass a thermometer dipping in the liquid, a tube also dipping in the liquid and drawn out to a fine orifice at the bottom, and another shorter tube open at both ends and not reaching the solvent. Air is caused to bubble through the solvent by means of the drawn-out tube, the evaporation thus produced serving to cool the nickeled tube, which acts as it does in Regnault's hygrometer. The author gives the necessary details to be attended to in the practical working of these three methods. T. H. P.

353. *Position of the Rare Earth Metals among the Elements.* **B. D. Steele.** (Chem. News, 84. pp. 245–247, Nov. 22, 1901.)—In the ordinary periodic grouping of the elements, there are fifteen blank spaces between cerium (at. wt. 140) and tantalum (183). The metals of the rare earths have atomic weights which would place them between these two elements, but their properties seem to indicate that they belong to the third group. The author assumes that these metals form an inter-periodic group which possesses certain analogies with the true groups of the periodic system. The two first groups of the classification comprise elements showing a distinct periodic variation in all their properties, and these are followed by two groups each containing seventeen elements, three of which do not exhibit a periodicity in their properties. On proceeding to the elements with higher atomic weights, the number of these inter-periodic elements increases, and it is among these that the author places the rare earth metals. Next comes a periodic group in which only thorium and uranium are known, and to which possibly radium and polonium belong. That there is no regular gradation in properties of iron, nickel, and cobalt, of the platinum metals, and of the rare earth metals, may be seen from the molecular volume curve of the typical oxides and from the curve of atomic volumes of the elements. In order to calculate some of these latter which are not known, the author starts from the fact that the atomic volume of oxygen in combination with the alkali and alkaline earth metals is negative, whilst in the oxides of silicon, phosphorus, sulphur, and chlorine it is positive, and in those of the intervening elements is zero. Further, in the oxides of zirconium, lanthanum, cerium, and thorium the atomic volume of oxygen has the values 0, 1, 2, and 2 respectively; the author assumes that in the rare earth metals it approximates to 1·5. On this basis it is found that these metals have small atomic volumes—a fact which is in agreement with (1) the observation of Abegg and Bodländer that small atomic volumes are possessed by elements with low electro-affinity, and (2) that of Stefan Meyer that this property is usually found with paramagnetic elements. T. H. P.

354. *Thermodynamics of Unsaturated Solutions.* **N. Schiller.** (Archives Néerlandaises, 6. pp. 497–549, 1901.)—This paper contains a treatment of unsaturated solutions similar to that previously applied to saturated solutions [see Abstract No. 1735 (1901)]. In particular, when only the solvent can evaporate, if σ is the specific volume of the pure solvent under pressure π, and σ' is the partial specific volume of the same solvent when a constituent of a solution of concentration ζ under external pressure $\pi + q$, q being the

corresponding osmotic pressure, the relation $\sigma' = \sigma(1 + \lambda_1\zeta)$, λ_1 depending only on π and the temperature, is shown to be true independently of any law of elastic compression, and of the form of the relation between the osmotic pressure and the concentration of the solution. W. E. T.

355. *Interaction of Calcium Ammonium, and of Lithium Ammonium, with Ammonium Chloride.* **H. Moissan.** (Comptes Rendus, 133. pp. 715–717, Nov. 4, 1901.)—Calcium ammonium, $Ca(NH_3)_4$, and lithium ammonium, $Li(NH_3)$, both react with ammonium chloride dissolved in liquefied ammonia at a temperature of $-80°$; but, under these conditions, ammonia and hydrogen are liberated, and the group (NH_4), cannot be isolated. D. H. J.

356. *Ammonium Amalgam.* **H. Moissan.** (Comptes Rendus, 133. pp. 803–808, Nov. 18, 1901.)—By the action of ammonium chloride or bromide in liquid ammonia on sodium amalgam, a metallic mass is obtained in which hydrogen and ammonia are present in stable combination at $-39°$; this metallic mass, on decomposing at the ordinary temperature in the absence of moisture, expands to thirty times its volume, and gives off two volumes of ammonia to one volume of hydrogen. D. H. J.

357. *Action of Various Metals Dissolved in Liquefied Ammonia on Hydrogen Sulphide.* **H. Moissan.** (Comptes Rendus, 133. pp. 771–774, Nov. 11, 1901.)—The author endeavours to obtain ammonium, NH_4, by the action of solutions of calcium and lithium in liquefied ammonia, on liquefied hydrogen sulphide. In each case the ammonium, if produced, dissociates at once into ammonia and hydrogen. W. C. B.

358. *Absorption Spectrum of Colloid Ferric Hydrate.* **B. E. Moore.** (Phys. Rev. 13 pp. 246–249, Oct., 1901.)—The author pointed out in a previous article [Abstract No. 1359 (1901)] that the final product of hydrolysis of ferric chloride could be compared with Graham's colloid ferric hydrate. On comparison, however, of the absorption spectra of the two solutions, he found that the curves for equal concentrations were quite different in character. In explanation of this, he adopts the view that the colloid ferric hydrate solution contains appreciable quantities of the crystalloid hydrate. E. C. C. B.

359. *Tin-Aluminium Alloys.* **L. Guillet.** (Comptes Rendus, 133. pp. 935–937, Dec. 2, 1901.)—By heating mixtures of granulated aluminium and stannic acid varying in composition between those corresponding with the formulæ Al_4Sn and $AlSn_3$, the author has isolated two compounds of the compositions Al_4Sn and $AlSn$, both of which form well-shaped lamellar crystals. T. H. P.

360. *Freezing-point Curves of Binary Alloys.* **A. W. Kapp.** (Ann. d. Physik, 6. 4. pp. 754–773, Dec., 1901. Extract from Dissertation, Königsberg, 1901.)—The author prepared alloys of Bi-Sn, Bi-Pb, Bi-Cd, Sn-Pb, Sn-Cd, Pb-Cd, by melting mixtures of varying proportions, increasing in steps of 10 per cent., in an iron crucible with thin walls, generally under a layer of charcoal, allowing the mass to cool slowly by placing the crucible within a block of wood lined with asbestos. He observed the freezing-points and the number of seconds during which the mass cooled by one scale division of about 6° C. Attention is drawn to the similar behaviour of mixtures of organic compounds. The author inclines to Ostwald's view, according to which either metal acts as solvent for the other, causing a depression of the freezing-point.

The fact that the lower fixed point has its highest value for the eutectic alloy he explains with Nernst by assuming that we observe an apparent freezing-point at which the heat lost by radiation is equal to the heat rendered free. As regards the composition of his alloys, as derived from his complete freezing-point curves, he does not agree with Guthrie. Rudberg and Guthrie are the chief authorities quoted. H. B.

361. *Solvent and Dissociating Properties of Liquid Cyanogen and of Hydrocyanic Acid.* **M. Centnerszwer.** (Zeitschr. Phys. Chem. 39. pp. 217–224, Dec. 5, 1901. Paper read before the Russischen Physiko-chemischen Gesell., Sept. 13, 1901.)—The author repeats and amplifies the work of Gore (Roy. Soc., Proc. 20. 67, 1872) on the solvent powers of liquid cyanogen; the latter came to the conclusion that this substance was inert, and in most cases did not act as a solvent. It has been shown that various substances, amongst them the organic cyanogen derivatives, are able to dissolve salts, especially the iodides, and that the bodies dissolved are partially ionised. For these reasons it is important to examine the solvent properties of liquid cyanogen.

Fifty-four substances were tested, including organic and inorganic chlorides, bromides, iodides, and cyanides; picric acid, trichloracetic acid, quinoline, di-phenyl-methane toluene and benzil. The only compounds found to dissolve were arsenic trichloride and tribromide, tin tetrachloride and tetrabromide; picric, trichloracetic, and tribromacetic acids; quinoline, acetonitrile, toluene, triphenyl-methane and benzil; antimony trichloride was also slightly soluble.

From the result obtained above it seems probable that liquid cyanogen will prove a very poor conductor of electricity; this is fully borne out by experiment, as the conductivity proves too small for measurement, although the cyanogen has undergone no special purification. The conductivity, in presence of many organic and inorganic salts, and other substances also, is so small as to be incapable of measurement.

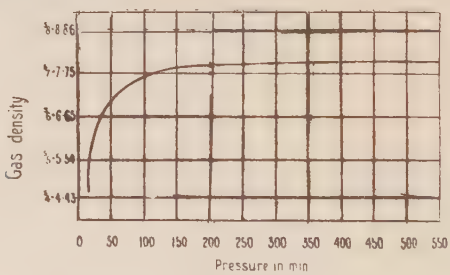
This proves that liquid cyanogen has very little solvent, and no ionising powers. According to Dutoit and Aston's hypothesis (Compt. Rend. 125. 240, 1897), only those solvents which are themselves associated show ionising power; from this the author concludes that liquid cyanogen molecules may have a simpler constitution than the gaseous molecules, and perhaps have the formula CN instead of C_2N_2. Other facts, notably its low boiling-point, tend in the same direction.

The second part of the paper consists of a research on the properties of hydrocyanic acid as a solvent. It has been shown that the dielectric constant for this substance is greater than that for water, and is only exceeded by that for hydrogen peroxide [see Schlundt, Abstract No. 1358 (1901)]; this, taken in conjunction with the fact that HCN is the lowest member of the nitrile series, renders it probable that it will prove an ionising solvent. This is fully borne out by experiment, as many salts dissolve easily in the liquid. The conductivity of pure hydrocyanic was found to vary, but the lowest value obtained was $0{\cdot}496 \times 10^{-5}$ reciprocal Siemens units. Tables of the molecular conductivities of potassium iodide and trimethyl sulphine iodide in hydrocyanic acid are given; and the values obtained show that these solutions conduct approximately four times as well as solutions of the same salts in water, at the same concentration and temperature. The conductivity is almost as large as that of aqueous solutions of the halogen acids at 25° C. These measurements show that hydrocyanic acid has a greater dissociating power than water; and this, taken in conjunction with the high value of the

dielectric constant, is another instance in support of the rule of Thomson and Nernst, as to the parallelism of these properties. W. C. B.

362. *Number of Ions in Metallammonium Compounds.* **E. Petersen.** (Zeitschr. Phys. Chem. 39. pp. 249–252, Dec. 5, 1901.)—A polemical paper, in which the author upholds his objections against Werner and Herty's method [see Abstract No. 127 (1902)] of determining the type of a salt; he states that the number of ions formed by a salt cannot be derived from the conductivity at a certain dilution. The author's measurements agree with those of Werner and Herty except for platinum-ammonia chloride, in which case the author explains the deviations as due to the non-identity of the two compounds examined. T. H. P.

363. *Dissociation of the Sulphur Molecule S_5.* **H. Biltz.** (Deutsch. Chem. Gesell., Ber. 34. pp. 2490–2495, Sept. 28, 1901.)—It was shown by Dumas that at a temperature near the boiling-point, the density of sulphur corresponded nearly with that required for the formula S_6, whilst Deville and Troost subsequently showed that above 860° values are obtained corresponding with the formula S_2. More recently cryoscopic and ebullioscopic methods have established the formula S_8 for solutions of sulphur in different solvents.



It has therefore been assumed that three kinds of sulphur molecules may exist together in equilibrium as represented by the equations—

$$S_8 \rightleftarrows S_6 + S_2 \rightleftarrows 4S_2.$$

Determinations of the vapour density at different temperatures, carried out by the author in 1888, gave no indication of a steady vapour density in the neighbourhood of the temperature at which values corresponding to the formula S_7 were obtained, but on the contrary the values increased steadily with falling temperature up to 7·8 at 468° C. the lowest temperature at which measurements were made; the calculated values are 6·65 for S_6, 7·75 for S_7 and 8·86 for S_8. The results then obtained by working at constant pressure have now been confirmed by a series of measurements made at constant temperature; the whole series of measurements was made at the boiling-point of sulphur, and the pressure was varied from 14·0 mm. to 539·2 mm.; the values obtained are shown in the accompanying curve. The density is seen to increase continuously from a low value to one in excess of that required for the formula S_7, and appears to be converging asymptotically to the line representing the density for the formula S_8; no break occurs in the neighbourhood of S_6, and there is absolutely no experimental evidence for the existence of this kind of molecule. T. M. L.

364. *Influence of Molecular State of Solvent on Diminution of Vapour Pressure by Dissolved Salts.* **J. D. van der Waals.** (Archives Néerlandaises, 4. pp. 332–340, 1901.)—Let $1-x$ and x denote the fractional molecular concentrations of solvent and solute. The molecular weights meant here are the simple chemical molecular weights. Suppose the solute is a binary electrolyte. Owing to ionisation, x separates into $x-y$ unionised molecules, and $2y$ ions. Suppose the solvent is partially associated to double molecules; $1-x$ gives $1-x-2z$ single, and z double molecules. Let p denote the vapour pressure of the solvent. The following law is then deduced thermodynamically, $-\frac{dp}{pdx}=\frac{x}{x-\frac{y}{2}}+\frac{x}{1-x+2z}$. When x approaches an infinitely small value, the expression on the right hand becomes $1\Big/\left(1-\frac{y}{2x}\right)$. As in this case $\frac{y}{x}=1$, the limiting value is 2. Hence for the limiting case of infinite dilution the molecular state of the solvent does not influence the value of dp/pdx. F. G. D.

365. *Electrolytic Preparation of Sesquioxide and Salts of Chromium from Alkali Chromates.* **P. Straneo.** (Elettricità, Milan, 20. pp. 627–628, Oct. 5, 1901. From the *Rivista Tecnica.*)—The limited production of oxide of chromium at the kathode during the electrolysis of an alkali chromate has been known for some time, and in the laboratory of the Royal Industrial Museum it was found that a quantitative yield could be obtained if sufficient time were allowed for the operation; if the chromate be acidified, electrolysis gives, quantitatively, a *salt* of chromium. Recently Street has patented in England and Germany a process for electrolysing the chromate, in which he employs a kathode of mercury. The present paper gives a brief critical description of Street's process. D. H. J.

366. *Electrolysis of Ammonium Chloride Dissolved in Liquefied Ammonia.* **H. Moissan.** (Comptes Rendus, 133. pp. 713–714, Nov. 4, 1901.)—The author finds that such electrolysis at temperatures between $-60°$ and $-80°$ furnishes only hydrogen at the negative pole and chlorine at the positive pole. [See also Abstracts Nos. 355 and 356 (1902).] D. H. J.

367. *Electrolytic Preparation of Monochlor-acetone and of Monobrom-acetone.* **A. Richard.** (Comptes Rendus, 133. pp. 878–880, Nov. 25, 1901.)—Monochlor-acetone is obtained by electrolysing a mixture of acetone and hydrochloric acid, and monobrom-acetone by a similar method. The yield increases with increasing voltage and with diminishing current density. D. H. J.

368. *Electrolytic Rectifier.* **E. Knoblauch.** (Phys. Zeitschr. 3. pp. 46–47, Nov. 1, 1901.)—The rectifier in question consists of a lead and an aluminium electrode standing in a 20 per cent. solution of sodium potassium tartrate (Rochelle salt). By means of it an alternating current may be employed with a Wehnelt interrupter for exciting induction coils in Röntgen-ray work. R. S. W.

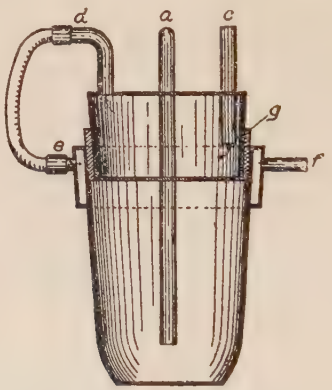
REFERENCE.

369. *The Significance of the Theory of Ions in Physiological Chemistry.* **T. Paul.** (Phys. Zeitschr. 3. pp. 28–31, Oct. 15, 1901. Paper read before the 73 Naturforscherversammlung at Hamburg.)

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

370. *Combustion Apparatus.* (Frank. Inst., Journ. 152. pp. 469–471, Dec., 1901.)—The Committee on Science and Arts of the Franklin Institute, issues a favourable report on the combustion apparatus invented by P. W. Shimer, of Easton, Pa., the object of which is to simplify the determination of carbon by the combustion method. Instead of the separate furnace with oxygen supply, and the usual tubes of platinum, porcelain, or glass, a platinum crucible is used, having the upper portion water-jacketed, with a water-cooled copper stopper provided with inlet and outlet tubes. A blast lamp and Bunsen burner supply the necessary heat, and air is



employed for the combustion. The woodcut shows the apparatus, the crucible having the form and dimensions of ordinary crucibles used for fusions. The water-cooled chamber is on the outside $\frac{1}{2}$ inch wide and $\frac{1}{8}$ inch deep, with short inlet and outlet tubes *e* and *f* placed horizontally on opposite sides. The hollow stopper, made of sheet copper, has a copper tube *a* passing through it for admission of air to the crucible : *c* and *d* are copper tubes for inlet and outlet of the cooling water, *g* is a small rubber band to make a tight joint between the stopper and the crucible, and it is protected by the water-cooled surfaces. The arrows show the direction of flow of the water. The usual absorption tubes and filter tube for air are employed. F. J. R.

371. *Economy of Clearance in Small Steam Engines.* **A. Kingsbury.** (Horseless Age, 8. pp. 796–797, Dec. 11, 1901. Paper read at the New York meeting of the American Society of Mechanical Engineers (Dec., 1901). Slightly condensed.)—The author made an elaborate series of tests to determine the effect of clearance on the economy of a small steam engine (having cylinder of 5 inches diameter and 7 inches stroke), and found that there was a regular increase in the water consumption from 52 to 56 lbs. per i.h.p. per hour, as the clearance was increased from 10 per cent. to 34 per cent. The increase of clearance, however, was accompanied by an increase in exhaust pressure, cor-

responding to less complete expansion, also by decrease in compression ; and these facts, together with the increase in clearance, were jointly responsible for the decrease in economy. E. H. C.-H.

372. *Automobile Boilers.* **J. W. Jones.** (Horseless Age, 8. pp. 817–819, Dec. 18, 1901.)—The suitability of various types of boilers for motor vehicles is considered, and also their relative economy. The author has compiled the following table from observations made during a recent 500-miles' road trial.

Type of Boiler.	Heating Surface in Square Feet.	Water Consumption (Speed, 15-18 Miles an Hour.	Water Consumption per Mile, in Gals.	Gasoline per Mile, in Gals.	Steam Pressure per Square Inch, in Lbs.
Victor fire tube.....	50	26 gal. 20[1]	1·3	1–6	200
Tol. water tube ...	36	35 gal. 30[1]	1·16	1–6	200
White flash	30	20 gal. 26[1]	0·77	1–6	150 to 250

[1] Miles travelled.
The weight of all carriages with supplies and equipment was about 1,350 pounds.
Each boiler is rated at 6 h.p.

C. R. D'E.

373. *Stearns Compound Engine.* (Horseless Age, 8. pp. 748–749, Nov. 27, 1901.)—This is a neatly designed compound vertical engine suited to light steam motor cars. Both cylinders have piston valves, and centrally between these is a third piston valve, which serves as a steam distributor to the h.p. valve for either direction of rotation of the engine, and also enables high-pressure steam to enter both h.p. and l.p. valve chambers when extra power is required. The chamber in which the distributing valve moves forms the receiver for compound working. All the running parts are carefully gear-cased. A good sectional elevation is given. C. R. D'E.

GAS AND OIL ENGINES.

374. *Nash Gas Engine.* (Eng. News, 46. pp. 327–328, Oct. 31, 1901.)—The article decribes, with a section drawing, a Nash gas engine of 125 h.p. It is a vertical engine with three cylinders, 13½ inches diameter and 16 inches stroke, and running at 225 r.p.m. The ignition is electric. Starting is effected by supplying one cylinder from a compressed-air engine, the other two being supplied with gas. G. H. B.

375. *Point of Ignition in Gas Engines.* **C. E Lucke.** (Horseless Age, 8. pp. 769–771, Dec. 4, 1901.)—An elaborate series of experiments was made with an Otto engine having a cylinder 5½ inches in diameter, with a 12-inch stroke. Sets of cards are reproduced, and the conclusion is arrived at that cards which have a vertical combustion line have not the greatest work area, but on the contrary, more work is turned out by the engine when the pressures do not rise so suddenly as to give a vertical combustion line. This is inexplicable except on the ground that at high pressures less heat is developed or more gets away suddenly, or that the specific heat of the gases rapidly increases with pressure. The author's results have been corroborated by a series of tests on a Fairbank Morse engine, reported in the Journal American Society of Mechanical Engineers, December, 1900. E. H. C.-H.

376. *Ignition.* **G. Lavergne.** (Locomotion Automobile, 8. pp. 753–754, Nov. 28, and pp. 769–770, Dec. 5, 1901.)—The Cannstat-Daimler firm are now using an alternating-current sparking apparatus having the advantages of the magneto while dispensing with any contact pieces subject to wear. Ignition by incandescence is based on the fact that spongy platinum or platinum wire will maintain incandescence when in contact with carburetted air. This system has no flame, and is not interfered with by wet or wind. Stoppage of the engine, or variation of the point of ignition, is easily determined by a valve controlling the admission of carburetted air on to the platinum. In this way a de Dion motor can be regulated over a range of 1,200 to 3,200 r.p.m. The objection to the method has chiefly been the danger of premature explosions, but this danger is absent in the Diesel motor, which only compresses pure air. E. H. C.-H.

377. *Dayton Dynamo for Electric Ignition.* **E. Dieudonné.** (Locomotion Automobile, 8. pp. 824–826, Dec. 26, 1901.)—This little machine is intended to replace the accumulators or dry cells usually fitted with the electric ignition apparatus of motor cars having internal combustion engines. It consists of a drum-wound armature, the spindle of which runs in bearings at either end of a barrel-shaped steel casing, which is permanently magnetised. The internal field poles are formed of soft iron, and the field coils are wound on them. The permanent magnetic field greatly facilitates the generation of sufficient current for starting the engine by hand. The armature spindle is driven by a friction cone controlled by a centrifugal governor, which causes the cone to slip above a certain speed. The machine weighs 10 kg., and developes 6 amperes 8 volts, at 1,400 r.p.m. C. R. D'E.

378. *Alcohol Motors.* **É. Hospitalier.** (Ind. Élect. 10. pp. 496–502, Nov. 10, 1901. Report of the trials instituted by the Minister of Agriculture.) —This paper contains full details of twenty-seven types of alcohol motors, together with the power and consumption figures on half and on full load. The tests were made with two grades of alcohol, viz., pure denaturalised alcohol, or "moto-schnick," consisting of 100 parts by volume of ethyl, 10 parts of methyl alcohol, and 0·5 part of heavy benzine, and "electrine" consisting of "moto-schnick" and light benzine in equal proportions. The b.h.p. trials were made with a Prony brake. The author points out the great advances which have been made in these motors during recent years, and that they now give practically the same power, for a given cylinder volume and piston speed, as petrol motors. C. R. D'E.

379. *Comparative Trials with Petrol and Alcohol.* **E. Dieudonné.** (Locomotion Automobile, 8. pp. 759–761, Nov. 28, 1901.)—This paper gives the results of experiments by H. Güldner on a single cylinder vertical engine, water-cooled and with electric ignition, cylinder 96 mm. bore × 100 mm. stroke, normal speed 1,000 r.p.m. The petrol used had a specific gravity of 0·68, and the alcohol was ordinary commercial alcohol of 88 to 90 per cent. purity. The horse-power was taken with a Prony brake. The average of the result gave 4·12 b.h.p. with petrol and 3·89 b.h.p. with alcohol. With petrol 351 gr. per b.h.p.-hour were consumed, and with alcohol 691 gr. per b.h.p.-hour. This is equivalent to 3,861 calories absorbed with petrol and 3,904 calories with alcohol per b.h.p.-hour, and a cost of 0 fr. 14 with petrol and 0 fr. 216 with alcohol per b.h.p.-hour, at present prices in Germany. A sectional elevation of the engine is given. C. R. D'E.

380. *Alcohol Motors.* **L. Perissé.** (Locomotion Automobile, 8. pp. 786–787, Dec. 12, 1901.)—This article gives the results of trials by Ringelmann at the trials organised by the Minister of Agriculture, France :—

(A) With alcohol carburetted with 50 per cent. of benzine. The consumptions per b.h.p.-hour were : Fritscher Houdry engine, 1·27 b.h.p. at 430 r.p.m., 645 gr. ; Aster engine, 2·3 b.h.p. at 1,600 r.p.m., 626 gr. ; Japy engine, 3·75 h.p. at 310 r.p.m., 409 gr. ; Otto engine, 6 b.h.p. at 240 r.p.m., 435 gr. ; Pruvost engine, 9·6 h.p. at 223 r.p.m., 379 gr. ; Merlin engine, 3 h.p. at 280 r.p.m., 529 gr. ; Bruhot engine, 16·1 h.p. at 176 r.p.m., 382 gr. Attention is directed to the comparison of these results with some obtained with an "Economique" engine tested in Switzerland. This engine gave 20·1 b.h.p. at 200 r.p.m., and consumed 272 gr. of 50 per cent. alcohol, 324 gr. of 80 per cent. alcohol (20 per cent. benzine), and 356 gr. of pure commercial alcohol per b.h.p.-hour

(B) With pure commercial alcohol the consumptions per b.h.p.-hour were as follows : Japy engine, 3·75 b.h.p. at 308 r.p.m., 565 gr. ; Pruvost engine, 9·6 h.p. at 222 r.p.m., 507 gr. ; Duplex engine, 8·2 h.p. at 230 r.p.m., 710 gr. ; Gnome engine, 4 h.p. at 368 r.p.m., 674 gr. ; Phoénix engine, 6·22 h.p. at 490 r.p.m., 688 gr. ; Bardon engine, 2·6 h.p. at 800 r.p.m., 862 gr. ; Bruhot engine, 16 b.h.p., 491 gr. ; "Economique" engine, 3·04 b.h.p. at 253 r.p.m., 475 gr. Engines by the same maker of 15 b.h.p. and 30 b.h.p. consumed respectively 356 gr. and 387 gr.

The author considers that the proportion of methylene added to alcohol in France should be reduced from 10 per cent. to 1 per cent. C. R. D'E.

381. *Centaure Motor.* **F. Mirès.** (Locomotion Automobile, 9. pp. 7–8, Jan. 2, 1902.)—This is a new type of petrol engine, built by the firm of Panhard and Levassor, Paris. It has four vertical cylinders cast in pairs, and bolted to an aluminium crank chamber. The cylinder bodies and heads are cast in one piece, and the induction valves are mounted vertically over the exhaust valves. The cylinders are water-cooled, and both tube and electric ignition are fitted. The cam gear for the exhaust valves is enclosed within the crank chamber, but the 2 to 1 gear and the governor are external, as in other engines by the same firm. The governor acts by restricting the admission to all cylinders equally. The engine developes 35 b.h.p. at 750 r.p.m., and weighs about 350 kilogrammes. C. R. D'E.

AUTOMOBILISM.[1]

382. *Motor Car Design.* **M. H. Smith.** (Inst. Mech. Engin., Proc. 3. pp. 699–717, 1901.)—The paper contains a description of the author's latest pattern of petrol car. The most interesting point is the use of belt-driving with cones for speed-change. A special form of link-belt was evolved, and is found very satisfactory. E. H. C.-H.

383. *Tractive Force Required in Automobiles.* **H. E. Wimperis.** (Écl. Électr. 29. pp. 330–334, Nov. 30, 1901.)—The author proposes to deal with the question by observing the time which a vehicle takes to slow down when left to itself. After the vehicle has reached full speed on a level road, he notes the rate at which the velocity decreases when the motive power is withdrawn. He then constructs a curve connecting the speed with the time, the latter

[1] Electric Automobiles are described in the Section dealing with Electric Traction.

being reckoned from the moment when the car is left to itself ; and thence he deduces a second curve connecting the speed with the distance travelled. The retarding force may be deduced by observing the time t which elapses during any small reduction of speed, say from 21 km. to 19 km. an hour. If M is the mass of the vehicle, the retarding force is given by the equation—

$$F = M \frac{\text{variation of speed.}}{t}$$

If t is made sufficiently small, approximations can be found to the value of F, and a curve can then be drawn connecting F with the velocity. In order to determine F with greater accuracy, recourse must be now had to analytical methods. The tractive resistance contains three terms ; the first is a term due to axle and rolling friction (Ewing has shown that rolling friction is independent of the speed, and depends solely on the pressure, and on the nature of the tyres and road surface) ; secondly, a term proportional to the speed, due to the roughness of the road ; thirdly, a term due to air resistance. The first two terms are proportional to the mass of the vehicle, but the third depends on the vertical surface exposed rather than on the mass. Nevertheless, we may assume that—

$$F = Mg(a + bv + cv^2),$$

where a, b, c are constants, and g is the acceleration due to gravity. The equation to be solved is therefore—

$$M\frac{dv}{dt} + Mg(a + bv + cv^2) = 0,$$

whence we get—

$$t = \frac{2}{fg}\tan^{-1}\frac{2cf(V - v)}{f^2 + (2cV + b)(2cv + b)},$$

where $f^2 = 4ac - b^2$, and V is the initial velocity. Similarly it is possible, on the above assumption, to obtain a relation between the distance travelled (d) and the velocity. Assuming certain values for a, b, and c, as deduced from the curve connecting F and v mentioned above, it will then be possible to see how far the theoretical values of t and d agree with the curves practically obtained. By the introduction of successive approximations, the values of a, b, and c can be obtained with considerable accuracy, in such a way as to make the theoretical calculations agree with the curves. The author contends that this method can be applied with great ease, the only laborious part of the work being that which involves the evaluation of a, b, and c. Thus in the case of a bicycle he has found that—

$$F = \frac{P}{132}\left(1 + \frac{v}{20} + \frac{v^2}{84}\right),$$

where F and P (weight) are calculated in pounds, and v in miles per hour.

W. H. S.

384. *René Legros Light Car.* (Locomotion Automobile, 8. pp. 774–776, Dec. 5, 1901.)—In the vehicle illustrated, a light channel steel underframe carries towards its front end a double cylinder vertical engine adapted to use either petrol or alcohol. The engine may, however, have one or more cylinders according to the power required. The power is transmitted through a cone clutch and a special form of spring drive to one shaft of the change speed gear. The changes of gear are effected by means of spur wheels which are always in gear, any one set being made drivers by means of

an arrangement of claw clutches. From the second motion gear shaft the power is transmitted through a jointed steel shaft to a bevel pinion which gears with a bevel wheel ring mounted on the exterior of the differential on the live rear axle. C. R. D'E.

385. *Delahaye Light Car.* (Locomotion Automobile, 8. pp. 790–791, Dec. 12, 1901.)—In this car a rectangular tubular underframe carries at its front end a horizontal single-cylinder engine, the crank-shaft of which is extended to one side, and carries a flywheel and a broad belt pulley. The engine is water-cooled, a pump and radiator being fitted. The carburettor is adapted for using either petrol or alcohol, and electric ignition is fitted. The power is transmitted by belt to a sleeve forming part of the differential gear-box, which is mounted upon a cross-shaft placed transversely to the length of the frame and parallel to the engine shaft. On the sleeve is a central loose pulley, and driving pulleys at either side of this give motion to the shaft for either forward or reverse motion of the car. When the belt is on the driving pulley which is outside the loose pulley the power is transmitted direct to the differential cross-shaft, while with the belt on the inner driving pulley, motion is first transmitted to a counter-shaft by spur gears giving the intermediate, lowest, or reverse speed, and then the motion is imparted to the differential sleeve and shaft through a spur drive. The power is finally transmitted to the road wheels by independent chain drives. Plan and elevation drawings of the mechanism and a photograph of the car are given. C. R. D'E.

386. *Panhard and Levassor Light Car.* **F. Mirès.** (Locomotion Automobile, 8. pp. 821–823, Dec. 26, 1901.)—In this vehicle the main underframe is of wood, and to it is attached a subsidiary metal frame supporting the engine and change gear. The engine is of the double cylinder vertical type, with pistons coupled to cranks at 180°. The cylinder dimensions are 80 mm. or 90 mm. bore and 120 mm. or 130 mm. stroke, for 5 or 7 b.h.p. at 750 r.p.m. The cylinders are water-cooled, and both tube and electric ignition are fitted. The engine is mounted towards the front of the frame, and the power is transmitted through a cone clutch to the change gear, which gives three speeds forward and one reverse, by means of spur wheels engaged by side contact, and is finally delivered to the road wheels from the differential cross-shaft by independent and chain drives. The differential cross shaft is carried in spherical bearings fixed at the junction of the metal and wood frames, and is thus relieved of strains resulting from deformation of the frames. C. R. D'E.

387. *Holden's Motor Bicycle.* (Automotor Journal, 6. pp. 95–100, Dec. 16, 1901.)—This bicycle has a tubular frame resembling a Warren girder in construction, the engine itself forming the bottom stay. In the spaces between the frame members are arranged the carburettor and petrol tank, the water tank, and the induction coil and battery. The engine has two horizontal cylinders, each with two pistons so arranged that either end of each cylinder body forms a combustion chamber, while the central portion of the cylinder wall in each case supports the guide of the single cross-head pin to which all four pistons are coupled. The guide-pin is free to turn in its guides, and has fixed to its ends long connecting rods which couple it to crank arms at the ends of the rear wheel axle. The rear wheel is of small diameter so as to admit a fair speed of rotation of the engine. The four combustion chambers of the engine are water-cooled, and have automatic admission and mechanically

operated exhaust valves. Electric ignition is employed, the four sparking plugs being fed from a single induction coil by means of a special high-tension distributor. A mechanical lubricator distributes oil to the cylinders. Several good illustrations are given. C. R. D'E.

388. *Brouhot Underframe and Gear.* (Locomotion Automobile, 8. pp. 793–794, Dec. 12, 1901.)—This mechanism consists of a rectangular tubular underframe carried by single plate springs from front and rear axles. The engine is of the double cylinder horizontal type, and is mounted with its longitudinal centre line on that of the underframe, and with crank-shaft practically at the centre of the length of the frame. The gear-box is mounted close up behind the crank chamber of the engine. At one end of the crank-shaft is mounted the flywheel and cone clutch, and on the clutch sleeve is a spur-wheel gearing, with a similar wheel on the first motion shaft of the change gear. By means of spur wheels and pinions three forward speeds and one reverse are obtained. The power is transmitted from the change gear to the live rear axle by a chain drive. There is no differential gear on the live axle, but the wheels are enabled to turn at different speeds by a special ratchet and paul drive. Plan and elevation of the mechanism are given, and a detail of the ratchet drive. C. R. D'E.

389. *Variable Speed Gear.* **G. Jougla.** (Locomotion Automobile, 9. pp. 8–10, Jan. 2, 1902.)—This gear, which is the invention of R. de Montais, is of the expanding belt pulley type. On each pulley shaft are two sliding bosses, with a fixed boss between them. To the sliding bosses are pivoted the inner ends of levers whose outer extremities are pivoted to the plates which form the pulley rim, and which are interlaced by a system of levers. On the fixed central boss are pivoted short arms which are also pivoted to the main pulley arms at the centre of their length. Spiral springs are mounted on the pulley shafts so that they press upon the sliding bosses and tend always to expand the pulleys by forcing together the sliding bosses. By means of a system of levers the sliding bosses of one of the pulleys are under control, and the diameter of this pulley can be varied at will. As one pulley expands, the other contracts, due to the increased belt tension. The belt may be caused to run loose by fixing the diameter of the pulley ordinarily under control and pulling out one loose boss of the other pulley, and so reducing its diameter. C. R. D'E.

390. *Suspension for Gasoline Motors.* **H. D. Meier.** (Horseless Age, 8. pp. 652–653, Nov. 6, 1901.)—The author criticises the usual methods of rigidly attaching the engines of motor cars to metal underframes, or in some cases direct to the rear axle itself. Certain methods of spring suspension are discussed, and two methods of applying rubber buffers between the supporting arms of a petrol engine and a channel or angle steel frame are illustrated. C. R. D'E.

REFERENCE.

391. *Air Navigation.* **H. Deslandres.** (Comptes Rendus, 133. pp. 993–996, Dec. 9, 1901.)—A method is given of determining the speed of a dirigible ærostat, with application to the experiments of Santos-Dumont. [See Abstract No. 2457 (1901).] E. H. C.-H.

GENERAL ELECTRICAL ENGINEERING.

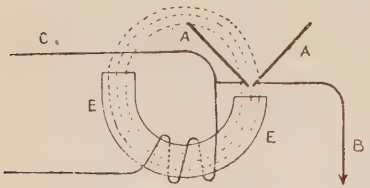
392. 10,000-*Volt Cable in* 1888. **O. Schaefer.** (Electrician, 48. pp. 178–180, Nov. 22, 1901.)—A cable with three strands, each of nineteen strands of 1·53 mm. in diameter, insulated with vulcanised rubber to a radial thickness of 4·25 mm. on each core, and also a cable with three cores of the same copper, insulated to the same radial depth with a material, mainly composed of hydrocarbons, called Kabelit, were laid underground for 3 miles in part of a 25-mile overhead transmission at 11,000 volts, from Meran to Bozen. They were tested to 20,000 volts, and after two years, in 1890, a fault developed in the rubber cables alone, and that near an exposed end. The author claims these to be the first stranded three-phase 10,000-volt cables ever made. The capacity per mile reaches the high figure of 0·78 microfarad per mile for rubber and 0·568 microfarad for Kabelit. M. O'G.

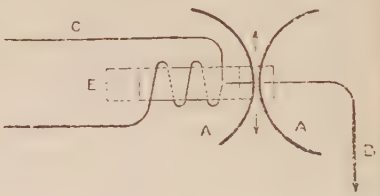
393. *Influence of Temperature upon the Output of Lead Accumulators.* **C. Liagre.** (Écl. Électr. 29. pp. 149–152, Nov. 2, 1901.)—After referring to previous results obtained by Gladsone and Tribe, and by C. Heim [see Abstracts Nos. 220 and 2465 (1901)], and also to the various formulæ for calculating the output of a cell, taking into account its rate of discharge, the author describes experiments made by himself upon a cell having electrodes, both positive and negative, of the Planté formed type. A number of different discharge rates from 25 to 180 amperes were selected, and at each rate a series of discharges was taken at temperatures ranging between 15° and 70° C. For each set of discharges the curve of increase of output with temperature proves to be a straight line, and all the lines have the same inclination to the axes, that is, they are parallel and indicate the same rate of increase in each case. The average coefficient of increase was 2·7 ampere-hours per deg. C., and it never varied through wider limits than 2·55 to 2·8 ampere-hours per deg. C. The lower the discharge rate, the bigger the output for any given temperature—this is also illustrated by curves—and it follows that the *percentage* increase of output with temperature goes up with the rate of discharge. The whole gist of the paper is to emphasise the relationship between these two variables. E. J. W.

394. *Magnetic Dynamometers.* **J. Guillaume.** (Écl. Électr. 29. pp. 189–196, Nov. 9; and pp. 265–276, Nov. 23, 1901.)—The method of ascertaining the h.p. of a motor by absorbing the power by means of a rotating disc of copper or iron cutting a magnetic field is discussed, and four types are described: (1) Siemens and Halske, (2) Pasqualini, (3) Feussner, and (4) Rieter. Photographs and drawings show the details and method of use in each case. The Rieter brake differs from the others in having the inductor part in construction like an alternator. In April, 1900, Rieter was presented with a medal by the Société Industrielle de Mulhouse for his invention, which was required to measure 20-h.p. to the one-fiftieth part at least. Experiments made by H. F. Weber with the brake are described. It is shown how the apparatus of Pasqualini may be used as an hysteresimeter. Finally a practical example of the use of the last-mentioned brake for testing at the electro-technical laboratory of the Italian navy at Spezzia is cited. W. W. H. G.

395. *Safety Devices for Protecting Overhead Lines against Dangerous Pressures.* **G. Benischke.** (Elekt. Runds. 19. pp. 39–41, Nov. 15; and pp. 50–52, Dec. 1, 1901.)—The lightning protector here described is designed to protect the lines also against rise of potential due to silent discharge, and has bow-shaped horns A, arranged as shown, in side elevation and plan, in the accompanying diagrams.

One of these horns is connected to earth through the conductor B, whilst the other is connected to the line C to be protected. This line is wound





once or oftener round a laminated iron core E, one of the poles of which lies below the sparking point, or place where the horns lie nearest together.

In another device, for protecting alternate-current mains from the effects of excessive pressure due to resonance, each of the lines is connected to one pole of a pair of adjustable sparking pieces, the other poles of which are connected together, and to earth, through non-inductive resistances—*e.g.*, water-resistances. C. K. F.

REFERENCE.

396. *Electric Crane.* (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1559–1561, Nov. 2, 1901.)—The article describes the construction of a crane, lifting 100 tons, erected on a wharf at Bremen. Several drawings are given, showing the general arrangements. W. H. S.

GENERATORS, MOTORS, AND TRANSFORMERS.

397. *Large Alternators.* **A. Rothert.** (Écl. Électr. 29. pp. 307–328, Nov. 30, and pp. 362–374, Dec. 7, 1901.)—The author gives a table containing full constructional details of twenty-three different types of large alternators, most of which were exhibited at Paris in 1900, and then briefly comments on the characteristic features of the various machines. The peripheral velocity varies from 14 to 38·5 metres per second. Of the twenty-three machines referred to, six had hole windings, eleven slot windings with the slots nearly but not quite closed at the top, and the remainder had entirely open slots. The number of slots per pole in the case of three-phasers varies from three to fifteen, the number most commonly employed being six; with only three slots per pole there is a very prominent third harmonic in the e.m.f. wave. The armature coils in almost every case have a width equal to the pole pitch. The air-gap varies from 6 to 8 mm. The pole-pieces are in some cases solid, in others laminated; in the author's opinion, they may be solid if, with at least six slots per pole (in the case of three-phasers), the width of the slot at the top does not exceed half the length of air-gap. The length of the pole-piece parallel to the armature circumference is in most cases two-thirds of the pitch. The current-density in the field coils mostly exceeds 3 amperes per sq. mm. (about 2,000 amperes per square inch), and in the armature coils falls below this value. The induction in the armature core-discs is in most cases 4,000 to 5,000 (for 50-cycle machines). The leakage coefficient of the field magnet varies from 1·18 to as high a value as 1·74; the author draws attention to the importance of calculating this coefficient. The ratio of armature to field ampere-turns seldom exceeds 0·3 (it varies between 0·15 and 0·47). The copper loss in the armature varies from 0·7 to 2·5 per cent., and the iron loss from 2·25 to 5·5 per cent., in most cases exceeding 4 per cent. The copper loss in the field varies from 0·36 to 2·6 per cent. The dimensions of different machines of the same output, and running at the same speed, vary considerably, and the author considers that there is plenty of scope for reducing the dimensions below their present-day values. A. H.

398. *Alternators with Dampers.* **J. Fischer-Hinnen.** (Elect. World and Engineer, 38. pp. 1058–1062, Dec. 28, 1901.)—The form of damper (amortisseur), originally described by Leblanc, consisted of a kind of copper ring on each magnetic pole of the alternator. Its effect was to reduce the drop of pressure by choking back part of the armature reaction. It was no real help for the parallel running of single-phase machines, as outside energy was required for synchronising the rotor. For polyphase machines, however, it was useful, as when they were running in synchronism no effect was produced on the damper, which acts only when the rotor gets out of synchronism. The author considers that the action of the damper is identical with that of the secondary winding of an asynchronous motor. He first of all developes the theory of polyphase motors, and then applies his formula to show the action of the dampers in polyphase generators. He investigates the problem of the influence of the damper on the working of a flywheel machine which has a variable speed on account of the unfavourable position of the crank. Under these circumstances he shows that the damper has some slight

influence on the uniform running of the machine. Its main use is to insure greater stability for paralleling. He considers that in many cases single-cylinder engines are preferable to compound engines. He points out that the change from maximum to minimum speed is steadier for a single-cylinder engine than for a compound engine, although, of course, the energy variations during each stroke are greater for the single-cylinder engine. The compound engine is much more likely to produce high harmonics in the e.m.f. wave. If a machine is run only for an hour or two at full load, and on a light load for the remainder of the day, then a good single-cylinder machine is the more economical in steam consumption. Some large generators, quite capable of supplying the night load, are yet not able to furnish the magnetising current for the transformers in the daytime, owing to the great pressure drop. For single-phase generators dampers are of very little use. They only reduce the pressure drop by about 30 per cent. Figures from actual machines are quoted to show that the weight of copper in the damper is about half that on the field. He says that the same purpose could have been attained at one-fifth the cost by strengthening the magnetic field. A. R.

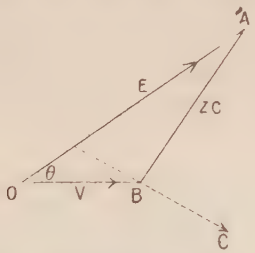
399. *Parallel Running of Alternators.* **E. J. Berg.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 781–785, Oct., 1901.)—A mathematical investigation is made of the principles governing the parallel running of alternators when driven by steam engines or turbines. It is proved that if we neglect the resistance of the armatures as compared with their inductance, then the alternators divide the load inversely as their reactances. Hence, if we have two machines running in phase, each of which generates the same e.m.f., then, if the armature reaction of one is double that of the other, it will only take one-third of the total load. To balance the load we must therefore—(1) add reactance to one armature, (2) rigidly connect the armatures together so that the e.m.f.'s are slightly out of phase, or (3) run them at excitations which will cause considerable cross currents. There is a definite tendency to "hunt," and this flow of power from one to the other is much greater than can be made up by the stored energy of the armature flywheels. It must, therefore, be supplied by the steam. Hence the flow of steam must be periodic to keep up the "hunting." The best remedy is to prevent this periodic flow of steam by proper dashpot arrangements at the governor. To use short-circuited windings in and around the field of the alternators is objectionable, owing to the losses due to the induced currents caused by the pulsations of flux incidental to the construction of modern ironclad armatures. A. R.

400. *Variations in the Exciting Current of an Inductor Alternator.* **W. Duddell** and **E. W. Marchant.** (Electrician, 48. pp. 224–225, Nov. 29, and pp. 302–304, Dec. 13, 1901.)—Measurements were made of the wave form of the exciting current of an inductor alternator by the Joubert contact method, and the authors give clear theoretical explanations of the results of their experiments. They prove (1) that the variations of the exciting current may be considerable in certain cases. (2) The exciting current is made up of a direct and an alternating current component, the frequency of the latter being double that of the armature e.m.f. (3) The added alternating current is asymmetrical. (4) The amplitude of this current depends very little on the resistance of the field circuit. (5) The maximum values of the exciting current on open circuit occur approximately when the armature e.m.f. has its maximum or minimum values. (6) In this case also the amplitude of the

exciting current is nearly proportional to the amplitude of the armature e.m.f. wave, the speed being kept constant, and (7) it is practically independent of the speed for constant mean exciting current. (8) The superimposed alternating current in the field is reduced when the machine is loaded, and becomes very small when the machine is short-circuited. (9) These variations in the exciting circuit tend to reduce the efficiency of the machine owing to hysteresis and eddy current losses. (10) The e.m.f. in the field coil may prove dangerous to insulation, &c., owing to resonance effects. The authors point out how this effect can be completely eliminated by properly designing the machine. A. R.

401. *Period of Natural Oscillation of Alternator Coupled to Bus-Bars.* **M. Soubrier.** (Écl. Électr. 29. pp. 177–178, Nov. 2, 1901.)—The approximate formula for the period of the oscillations of the rotor of an alternator connected to the bus-bars has been given by Blondel and Boucherot. [See Abstracts Nos. 340 and 341 (1900).]

A simple proof of the formula can be given as follows: In the figure let OA be the vector e.m.f. of the alternator and OB(V) the p.d. between the bus-bars, then BA will equal ZC where Z is the impedance of the armature and C is the current. Suppose that the resistance of the armature is



negligible compared to its inductance so that BC the current vector is perpendicular to AB, then if P be the power given to the network by the alternator,

$$P = EC \cos \hat{EC} = \frac{AO \cdot AB \sin A}{Z} = OB \cdot \frac{OA}{Z} \sin \theta = VI \sin \theta.$$

Hence if θ be small the retardation of the rotor is proportional to θ; the motion is therefore simple harmonic, and—

$$T = 2\pi n \sqrt{\frac{2\pi M K^2}{f V I}},$$

where T = the period of the oscillation in seconds, n = the number of revolutions per second, M = the mass of the rotor in kilogrammes, K = its radius of gyration in metres, f = the frequency, V = the bus-bar voltage, I = the short-circuit current of the alternator. A. R.

402. *Study of Polyphase Machines by the Oscillograph.* **A. Blondel.** (Écl. Électr. 29. pp. 391–400, Dec. 14, 1901.)—Complete data are given of experiments on a two-phase and a three-phase machine, which were driven by a direct-current motor connected to a battery of accumulators so as to insure constant speed. The characteristic curves are given of the machines on open circuit, on inductive and non-inductive loads, and on short circuit. Experi-

ments were also made to find out how the voltages in the various phases altered when one was loaded and the others left on open circuit. The results agree very closely with those arrived at by the ordinary theory. When, however, the instantaneous values of the exciting current, the volts and the armature currents, were oscillographed, very curious effects were observed. On open circuit the three-phaser gave a very approximate sine curve, and the exciting current was practically a straight line. When one phase was loaded the exciting current pulsated with a frequency twice that of the alternating current (see Blondel, *La Lumière Électrique*, Sept. 12, 1891). When the three phases were loaded symmetrically the frequency was six times that of the armature current, but the amplitude of the disturbance was much smaller. Similarly in the two-phase machine the frequency of the pulsation of the exciting current was four times that of the armature current.

A non-inductive load on one of the phases lowers the e.m.f.'s in the others. If the load be a capacity load, then the other e.m.f.'s may be slightly raised. The shapes of the p.d. waves on unequal loads are of course quite different. In the three-phaser the shape of the p.d. wave across the loaded phase is approximately sinoidal, that across another is a peaky wave, and across the third a flattened wave. In the two-phaser the effects of the armature slots on the shape of the p.d. wave are very pronounced, making it rippled. When one phase is loaded enormous distortions from the sine shape are produced. One p.d. wave becomes peaky and the other flattened. When one phase is short-circuited the p.d. wave in the other phase loses its symmetry, and the pulsations of the exciting current are very large. It is curious that these effects do not alter very appreciably the characteristics of the machines.

A. R.

403. *Measurement of Slip in Induction Motors.* **A. Schweitzer.** (Elektrotechn. Zeitschr. 22. p. 947, Nov. 14, 1901.)—The stroboscopic method of measuring the slip in an induction motor, first described by Benischke, is frequently employed, a simple white mark on the rotor being viewed by the light coming from an arc lamp fed from the circuit supplying the motor. The number of apparent revolutions of the white mark during a given time enables us to find the slip. The objection to the use of an arc lamp is the comparatively large current which it takes. The author has tried the use of incandescent lamps for this purpose [following a suggestion of Samojloff's, see Abstract No. 117 (1901)], but finds them unsatisfactory. A Braun tube may, however, be used with advantage. The induction coil supplying the tube is worked by an interrupter driven by the rotor of the motor under test, and the rotating field which produces the deflection of the kathode rays is due to suitably arranged coils connected to the generator. From the number of apparent revolutions of the luminescent spot on the screen of the tube, corresponding to a given number of rotor revolutions, the slip is at once obtained.

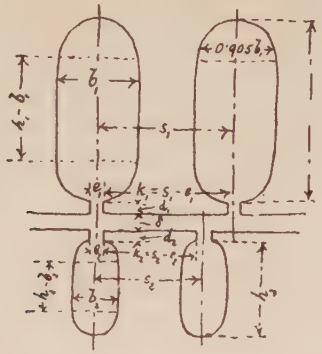
A. H.

404. *Calculation of Three-phase Induction Motors.* **O. Weisshaar.** (Elektrotechn. Zeitschr. 22. pp. 943–947, Nov. 14, 1901.)—After a brief discussion of the induction motor diagram, the author gives the following formula for the leakage factor τ_1 of the stator (*i.e.*, ratio of stator leakage flux to main flux)—

$$\tau_1 = \frac{4\delta}{\frac{3}{2}(q_1 k_1 + q_2 k_2)}\left(\frac{h_1 - b_1}{q_1 b_1} + \frac{1}{0{\cdot}905 q_1} + \frac{e_1}{d_1} + \frac{2\delta}{\frac{3}{2}(q_1 s_1 + q_2 s_2)}\right),$$

where the meanings of most of the symbols are evident from the accompany-

ig sketch, and q_1, q_2 denote the number of stator and rotor slots respectively er pole and per phase. The rotor leakage coefficient τ_2 (ratio of rotor akage flux to main flux) is obtained by interchanging the suffixes 1 and 2 in



he above formula. Two numerical examples are worked out, and the alculated results agree very well with those obtained experimentally. [See urther Abstract No. 1939 (1900).] A. H.

405. *Regulation of Rotary Converters.* **A. Blondel.** (Écl. Électr. 29. pp. 206–217, Nov. 9 ; and pp. 283–293, Nov. 23, 1901. Paper read before the Congrès Intern. des Électriciens.)—The theory of the regulation of rotary converters is discussed by means of simple diagrams. The method of treatment is similar to that used in the author's theory of synchronous motors [see Abstract No. 2010 (1901)]. He considers the magnetic field as due to three magnetomotive forces : (1) The ampere turns of the exciting current ; (2) the ampere turns in the armature which are "wattless" with regard to the applied p.d. ; and (3) the difference between the "watt" ampere turns and the secondary ampere turns produced by the direct current. (1) and (2) act in the same direction. (3) is always extremely small and can be neglected in practice. Hence, in theory, a converter can be considered as a simple case of a synchronous motor, namely, the case when the cross magnetisation of the armature can be neglected. The author's "principle of two reactions" is thus directly applicable. He uses very similar diagrams to those he employs for alternators and motors, the e.m.f.'s and the currents being represented on the same diagram by different scales and from different polar axes. He gives a formula for the most advantageous reactance of the converter when supplied at constant p.d. The most perfect theoretical way of regulating the converter would be to alter the applied p.d. in such a way that the converter would have practically unit power factor at all loads. This could be done by a suitable alternator. If the applied p.d. is constant, then suitable choking coils have to be put in series with the converter. In the second part of the paper the best ways of exciting the converter in various cases are determined. When the regulation is effected by choking coils and the applied p.d. is constant, then a simple shunt winding is suitable. If the applied p.d. increases with the load, then a compound winding is best, the shunt windings required being determined by the voltage of the unloaded machine, and the series windings by the voltage at full load. The diagrams given by the author can be combined with experimental data so as to give exact numerical results. A. R.

406. *Constant Current Transformer for Alternating Series Arc Lighting.* (Frank. Inst., Journ. 152. pp. 355–369, Nov., 1901. Report of the Franklin Institute on the invention of Prof. Elihu Thomson.)—This transformer is intended to have its primary connected to an alternating circuit of constant potential, and to deliver from its secondary a constant current of varying potential. It is designed to run on commercial circuits of 1,100 or 2,200 volts, the secondary output being 6·6 amperes at any pressure up to 6,000 volts.

The sizes made are for 25, 50, 75, and 100 lights. The primary coil is fixed, the secondary being suspended above it from the end of a lever, and balanced by an adjustable weight outside the transformer. Connections to the secondary are made by flexible wires. A core of iron stampings passes through the centre of the coils, the magnetic circuit being completed outside the coils. The transformer case is filled with transil oil, which steadies the motion of the movable coil, as well as cools the transformer. The outside of the case is corrugated to help the dissipation of heat. Larger sizes are made with two fixed primaries, between which the two movable secondaries are placed, joined by an equalising chain, so that an upward motion of the one corresponds with an equal downward motion of the other. The lever which carries the counterweight has a sector at the end of it which can be tilted at various angles ; altering the weight changes the average current, while tilting the sector varies the strength of the current through the range of the machine. With a change in the external circuit, the secondary, under the influence of the repulsion of the primary, and the lifting action of the lever, assumes a new position of equilibrium, in which fewer or more lines of force due to the primary are cut by the secondary, according as the latter has approached or receded from the primary. The effect is that the secondary voltage is increased or diminished as the case may be, and the secondary current remains practically constant. The primary current also remains nearly constant, but with an increased angle of lag at lighter loads. Curves and tables are given showing the result of a test made on a 50-light transformer with 2,200 volts on the primary at 60 periods. When the number of lamps on the secondary was varied from 50 to 15 by steps, and back again, the current only varied between 6·52 and 6·7 amperes ; the volts per lamp, however, increased as the load was diminished from about 77 to 86. This is explained as being due to the alteration in the current wave form, the curve becoming less peaked. On account of this action the makers adjust the transformer so as to give approximately constant watts per lamp. B. P. S.

REFERENCE.

407. *Breakdowns of Electrical Machinery.* **M. Longridge.** (Mech. Eng. 8. pp. 456–458, Oct. 5, 1901.)—This paper is a reprint of a portion of the author's annual report as chief engineer of the Engine, Boiler, and Employers' Liability Insurance Company, and contains a summary of the more important breakdowns in connection with dynamos and motors that have come under the notice of the company during the past year.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

408. *Cost of Power.* **C. D. Gray.** (Frank. Inst., Journ. 152. pp. 275–293, Oct.; 331–350, Nov.; and pp. 421–439, Dec., 1901.)—The paper is a valuable collection of data on costs and efficiencies of different power engines. *Man Power.*—Average value for steady work $\frac{1}{10}$ h.p. *Animal Power.*—Average values for steady work in drawing load: Horse, 0·785 h.p.; ox, 0·66 h.p.; mule, 0·50 h.p.; ass, 0·25 h.p. Cost of one h.p. year, including interest, depreciation, and driver, £89. *Water Power.*—Tables are given of efficiency tests. Tangential wheels have efficiencies of from 85 to 90 per cent. in large sizes and from 75 to 85 in small sizes at full load. Turbines have efficiencies of from 80 to 85 per cent. above three-quarter load. The capital cost of water-power plants is £8 to £12 per b.h.p. excluding dam, and £12 to £20 including dam. Costs per h.p. year are given for 12 plants, and vary from 25 to 90 shillings; the average is 43 shillings. *Steam Power.*—A large number of tests of American coal show a calorific value of 14,450 B.Th.U. for anthracite and 14,470 for bituminous coal per lb. Heavy Pennsylvania petroleum gives on the average 20,000 B.Th.U. per lb.; light, 18,000, and Ohio and West Virginia oils give 18,500 per lb. Results of 192 boiler tests are given, showing an average evaporative power for all kinds of coal of 10·8 lbs. of water per lb. of coal for water-tube boilers, and 10·4 for tubular boilers, the steam temperature being 212° F. Figures of 250 engine tests are quoted; the averages, expressed in lbs. of steam per i.h.p., are :—

	Slide Valve.	Corliss.
Simple, non-condensing	33·8	29·0
Compound „	26·2	24·0
Simple condensing	23·1	22·6
Compound „	20·6	17·7
Triple „	17·0	14·2
Large pumping engines, simple	19·9	
„ „ compound	15·3	
„ „ triple	12·3	

A table is given of steam-power costs per h.p.-hour; the standing costs vary from 0·045d. to 0·37d., the operating costs from 0·115d. to 1·22d., and the total costs from 0·155d. to 1·45d. The average total cost is 0·475d. For large compound condensing engines the average is 0·353d. *Gas Engines.*—Tables of calorific values of different gases give the following average values expressed in B.Th.U. per cub. feet. :—

Natural gas	1,033
Coal gas	706
Water gas carburetted	651
„ uncarburetted	319
Producer gas	143
Blast-furnace gas	102

Tests of gas engines give the following averages :—

Natural gas	9·85 cub. ft. per b.h.p.
Coal gas, small engines	22·9 „ „
Producer gas	82·0 „ „
„	62·9 „ per i.h.p.
„	1·04 lbs. coal per i.h.p.
Blast-furnace gas.....	115 cub. ft. per b.h.p.

Tables of costs are given of power from gas engines and of electric power for lighting and for traction ; also of efficiencies of electrical machinery, of different illuminants, and of power transmission systems. G. H. B.

409. *Power Distribution.* **C. F. Scott.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 821–826, Nov., 1901.)—The question here discussed relates to the distribution of energy from alternate current generators, and the author enquires whether it is desirable to convert to direct current by means of rotary converters, and if so, under what circumstances. His views may be summarised as follows. Incandescent lighting can be carried out equally well either by alternate or direct current ; arc lighting, now most extensively carried out by enclosed arc lamps, can be provided either by direct current or by 60-cycle alternate current ; the Nernst lamp works well on alternate current but not on direct current ; for motor work there is little to choose, except in those cases in which a variable speed is required, while for constant speed work "probably no one will question the superiority of the induction motor from the standpoint of the man who uses the motor and pays for the repairs," and objections as to power factor, starting current, and voltage regulation can be met by a proper design of the system. On the whole from these points of view there appears to be little to choose. But when the matter is considered from the point of view of cost, simplicity, &c., the direct current appears at a disadvantage. The great difference arises in the matter of sub-stations. For power distributed by alternate current the substations contain merely static transformers, which can be placed in any convenient position, and their number is comparatively unimportant. If the power is to be distributed in the form of direct current the substations must contain switchboards, transformers, rotary converters with further switchboards ; these are expensive to install and to operate, and it is desirable to have as few distributing centres as possible. The number of such substations is therefore made as small as possible, and they are placed as great a distance apart as the distributing circuits will allow. This of course further reacts on the cost of the distributing circuits, which is very much greater than for the low tension alternating current circuits to which current is supplied from a large number of transforming points. Accumulators can obviously be used on either system ; in connection with alternate current distribution, a rotary converter charges the battery, which in its turn supplies current through the converter to the alternating circuits. A combination of the two systems may be desirable. Thus in country districts alternators supply tramways through 60-cycle rotary converters, the ordinary lighting and power work being carried out by alternate current ; the whole is supplied from one set of bus-bars, as the automatic compounding of rotary converters is such as to keep the voltage on the lighting network practically constant. W. H. S.

410. *Power Distribution by Alternate Current.* **W. S. Barstow.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 827–831, Nov., 1901.)—The old system of house-to-house distribution was superseded by an attempt to inter-connect the secondaries; but it was soon found that the attempt to run transformers in parallel on the small secondary mains then existing was like paralleling compound generators through a small equalising bus-bar. Although by increasing the size of the secondary mains, the trouble was temporarily avoided, the system to-day has almost reverted to a house-to-house supply, although the transformers are arranged in groups, and are provided in case of accident with means for inter-connection. The only method of running transformers in parallel is to place each bank of transformers on a separate feeder, and to provide means for regulating the voltage on such feeders, so making it possible to divide up the load on the different transformers, and to compensate for any difference in transformer regulation. The advent of the multiphase motor has greatly contributed to the development of two- and three-phase distribution. On the biphase system, the best commercial form of distribution is by means of four conductors on the secondary side; and with the same number of conductors a saving of copper is secured by the use of three-phase current. If the secondary pressure is 110 volts, either large motors must be installed at this pressure, or step-up transformers used; in any case, the mains must be large enough to allow for the starting and stopping of such motors. The mains used are often far too small, and this has probably arisen from a mistaken interpretation of the idea that the alternating system saves copper. W. H. S.

411. *High-frequency Oscillations in High-Potential Transmission Lines.* **C. P. Steinmetz.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 705–727, Oct., 1901.)—This paper contains a detailed theoretical investigation of the irregularities in the p.d. and current waves obtained at the instant of closing or opening a high-potential alternating current circuit possessing resistance, inductance, and capacity, and of the effects produced in such a circuit by the occurrence of a short-circuiting, self-interrupting arc. In dealing with a transmission line, the author assumes that the capacity is concentrated at the middle point of the line. The main conclusions arrived at are the following: (1) The most important source of destructive high-voltage phenomena in high-potential circuits containing inductance and capacity are not resonance phenomena with the wave of impressed e.m.f. or any of its harmonics, but electric oscillations produced by a change of the condition of the circuit, such as closing, opening, or short-circuiting by an arc. (2) These effects are independent of the frequency and wave-shape of the impressed e.m.f., and depend on the nature of the change which is brought about in the circuit, and on the phase of the e.m.f. at the instant at which the change takes place. (3) No dangerous rise of potential takes place in *closing* the circuit; but the oscillations set up on *opening* it when under load may become destructive if the instant of opening is in the neighbourhood of maximum value of the current. (4) If a short-circuit occurs by the formation of an arc, then at the instant of interrupting the arc the p.d. may reach values far beyond the strength of any insulation. In this case, also, the p.d. will not be excessive if the current has a small value at the instant at which the arc is interrupted.—A number of diagrams plotted by the author from the theoretical equations illustrate these results. A. H.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

412. *Niagara Falls Power Transmission Plant.* **L. B. Stillwell.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 541–627, Aug.–Sept., 1901.)—The paper contains an illustrated historical account of the development of the Niagara Falls Power Transmission System, with a critical discussion of the original plant and of the various modifications which have been introduced. The author adduces the history as a "demonstration of the ability of applied electrical engineering science to attain in commercial practice results predicated in large degree upon theory." The load curve for local service for the twenty-four hours ending at midnight on July 20, 1901, affords an interesting example of the high load factor that may be obtained from a large plant which supplies most of its power to factories in which the processes employed are continuous, the minimum local load during this period being 14,200 kw., and the maximum 15,700 kw. The author states that during the two years ending with June, 1901, the cost of maintenance and repairs has been less than 1 per cent. in the case of the generating plant, including alternators, exciters and switch gear; and about 2 per cent. for the motive power plant, including turbines, governors, pen-stocks, shafts, inlet racks, &c.

G. W. DE T.

413. *Electric Power at Jajce.* **J. B. C. Kershaw.** (Cassier, 20. pp. 443–453, Oct., 1901.)—This station was planned and constructed by Schuckert and Co. for the utilisation of the water power available there for chemical manufacturing purposes. The water supply is drawn from a lake on the Pliva River, 129 feet above the power-house, and which has had its storage capacity increased by means of timbering to 15,000,000 cubic feet. A supply canal, about one-third of which is tunnelled and the rest open, carries the water for a distance of 3,382 yards down the river valley. Two pen-stocks lead the water from the end of the canal to the power-house. The head of water is about 110 feet, and the flow varies from 494 to 10,590 cubic feet a second, according to the season. The two pipe lines supply two rows of five turbines each, in the power-house, these turbines being of the reaction Francis type with horizontal axes. Eight of them give 1,000 h.p. each at 300 r.p.m., and drive by flexible couplings, triphase Schuckert generators in parallel. Governing is effected by a hand-controlled electrical device operated from the switchboard. The two remaining turbines develope 632 h.p. each, and are directly coupled to continuous-current Schuckert generators. Each alternator has a capacity of 3,000 amperes at 350 volts, this current being used for calcium carbide manufacture. The two continuous-current machines have a combined capacity of 7,200 amperes at 120 volts, and this current is employed for the manufacture of alkalies and chlorine.

G. W. DE T.

414. *Hackney Electricity Works.* (Electrician, 48. pp. 43–44, Nov. 1, 1901.)—This article contains a brief preliminary description of the work at present done. Sufficient progress has been made to start the supply; but the work will not be completed for some time. The site of 5 acres is on the river Lea, at a considerable distance from the centre of Hackney, the longest feeder being 2½ miles in length. The refuse destructor consists of 12 cells, which supply heat to three boilers; these are together supposed to be able to evaporate 15,000 lbs. of steam per hour, when heated with the destructor gases. There are also three Babcock boilers with superheaters, in another boiler-house on

the further side of the engine-room. The chimney is 200 feet high, and has a diameter of 9 feet. The engine-room is 130 feet by 50 feet, and has a 15-ton crane. Current is supplied on the continuous-current system. The plant includes two 1,000-h.p. Bellis engines, and two 500-h.p. Willans engines, coupled respectively to 600-kw. and 300-kw. dynamos by Holmes. The switchboard is by Ferranti, the generator and feeder panels being placed back to back. The battery consists of 304 Tudor cells giving 700 amperes for four hours. Cables have already been laid in 25 miles of streets on the solid system in earthenware troughs with spigot and socket joints. Both feeders and distributors are triple concentric. Nine miles of streets will be lighted by 293 arc lamps. The price charged will be 4d. per unit for lighting and 2d. for power. W. H. S.

415. *Power Distribution in Buffalo.* **H. W. Buck.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 813–819, Nov., 1901.)—This paper covers very similar ground to those noticed in Abstracts Nos. 2031, 2032, and 2290 (1901); it nevertheless contains a useful summary of the present position in Buffalo. A general map is given showing the transmission lines from Niagara to Buffalo, Tonawanda, and Lockport; also a diagram showing the connections at the Buffalo Terminal House; and another showing the 11,000-volt cable system in Buffalo, together with the position and arrangement of the circuit-breakers and section-switches. A drawing is given of the section-switches, which are used on 11,000 volts, and placed underground in vaults at convenient intervals; they are used for testing and repairing purposes, and are recommended for use on all high-tension cable systems. A list of the substations is also given, and the power supplied by each and the purpose for which it is supplied is also stated. As is well known, the Niagara pressure of 22,000 volts is reduced by transformation to 11,000 volts as soon as Buffalo is reached. The transmission line is overhead, but the distribution in Buffalo is by underground cables. It was considered that 11,000 volts was the highest safe pressure for underground work, which involved many lateral connections, frequent joints, section-switches, and switchboard connections. Higher underground pressures have indeed been used than even 22,000 volts, notably in the case of the St. Croix Power Company [see Abstract No. 716 (1901)]; but what can be done safely on a through trunk line cannot be done on a network. In the case of a short circuit practically no damage is done to the cables at 11,000 volts on account of the small current carried. Short circuits have occurred on the Buffalo cables, and it has been found that the lead was barely melted off round the fault. Inquiries have been made as to why the power is not transmitted from Niagara at 11,000 volts, and then distributed without transformation. It is stated, however, that the saving in copper on the transmission lines by the use of 22,000 volts more than pays for the transformer installation in the terminal house, and that the saving in line loss is greater than the loss introduced by the step-down transformers. W. H. S.

416. *United Railways and Electric Company of Baltimore's New Boiler Plant.* (Eng. Record, 44. pp. 419–422, Nov. 2, 1901.)—Full details with sectional views are given of the construction of the 94 feet by 131½ feet building which has been erected for the boiler plant of the United Railways and Electric Company of Baltimore, which intends to consolidate its present twelve or thirteen power stations, and house all the machinery under one roof. At present 4,000 h.p., out of a total of 16,000 h.p. ultimately wanted, have been installed, the boilers being of Babcock and Wilcox design in 500-h.p. units placed in

batteries of two. Ultimately there will be four batteries on each side, making eight on each floor, with a stack for each four batteries of 4,000 h.p. Roney stokers are used, driven by 6-h.p. Westinghouse engines with 4½ by 6-inch cylinders, each driving-shaft having an engine at each end and running the entire length of the building. In all, eight engines will be used. The boilers are constructed each of 216 4-inch tubes 18 feet long, laid 12 high and 18 wide, and two 42-inch drums 22 feet long.

Feed-water from the city mains first circulates round the bearings of the large direct-coupled engines and then passes into National heaters in which the exhaust steam from the main engines is used. From these it is conveyed to Warren-Webster open heaters, using the exhaust steam from the auxiliary engines and pumps, and reaches the boilers at a temperature of 208° F. Feed-pumps are of Blake vertical compound type with cylinders 10 and 18 inches by 10 inches.

The stacks are of steel, brick-lined, 200 feet high and 13½ feet inside diameter, with four openings for smoke-flues, two on each floor of the boiler-house. The stacks are in the centre of the building, and the boilers are placed back to back against them. Coal is raised from either rail or water by a hoisting-tower whose base spans the street railway and adjoins the quay. The tower is 183 feet high, and a duplicate will be required for the complete plant. The engine platform is 120 feet above the street level, along with the coal hopper, a crusher hopper and car being below at 102 feet. A horizontal boom 52 feet long extends over the water 146 feet above it, and buckets are raised and lowered from the boom by electrically driven winding drums. Each round trip of a bucket weighing 2,900 lbs., with its load of coal 2,200 lbs., has to be made in 72 seconds, the guaranteed performance of the whole being 50 tons per hour. As the gears transmitting turning effort to the hoisting-drums should not be subjected to shocks by sudden applications of power, acceleration is made smooth and controllable by the armature of the hoist-motor deriving its current from a generator which is motor-driven. The fields of the hoist-motor are excited direct from the feeder which supplies the motor driving the generator. A foot-operated rheostat controls the e.m.f. of the generator field. The current flowing through the armature of the hoist-motor is proportional to that e.m.f., and its torque is proportional to the controlled field strength. The buckets are lowered by gravity, brakes being used at present, but an effort is to be made to utilise the gravity force to generate electric current. An automatic railway carries the crushed coal to the main hoppers, and a bucket-conveyor takes the ashes from hoppers under the fire-boxes of the boilers, along the building, and up to an ash chute at the top, down which they fall by gravity into an ash tank placed in the hoisting-tower. They can be withdrawn from this to either cars or vessels. The original article must be consulted for the details of the building and the sectional and other illustrations which are given. F. J. R.

417. *Versailles Electric Railway.* **F. Drouin.** (Génie Civil, 39. pp. 413–419, Oct. 26, 1901.)—The line from the Invalides to Versailles, which has been equipped electrically, is supplied from the station at Moulineaux. [See Abstract No. 226 (1902).] The system of supply is three-phase current at 5,000 volts, which is converted by rotaries to continuous current at 500 volts. Of the six cables leaving the station, two go to Meudon and Viroflay, and four to a distributing box at the Pont de Passy, from which two go to the Invalides, two to the Champ-de-Mars, and one to Courcelles. The cables are constructed on the Berthoud-Borel system, in which the wire of the outer strands of each

core is separately insulated; each core is paper-insulated, and the three are made up with jute worming, and the whole insulated with paper, covered with two layers of lead, and then with an armouring of two steel ribbons. The sections of each core vary from 100 to 150 sq. mm. The cables are laid at a depth of half a metre in the ballast close to the track. There are three main substations, at the Champ-de-Mars, Meudon, and Viroflay. Each contains four Thomson-Houston rotary converters of 300 kw. normal and 450 kw. maximum capacity. The pressure is regulated on the alternate-current side, by a regulating transformer with movable armature. Each rotary is supplied by a group of three transformers in triangle, reducing the pressure to 340 volts. They are ventilated by a fan driven by an induction motor. The rotaries are started by continuous current supplied from a 40-kw. generator driven by an induction motor. There are also substations for lighting and pumping at each station on the line. The line is supplied by a third rail of the same section as the track rails, and weighing 46 kilos per metre. They are supported on projecting sleepers by chairs fixed to insulators of paraffined wood, and are divided into sections of one kilometre. In laying the track an erecting car drawn by a steam locomotive was employed. This contained a 45-h.p. engine and dynamo, supplied with steam from the locomotive; the current was used for lighting and for electric drills carried on trolleys.

The electric locomotives, ten in number, are capable of drawing a load of 200 tons at a speed of 50 km. per hour up an incline of 1 per cent. Their length is 13 metres and weight complete 50 tons. Four have geared Thomson-Houston motors, and six have direct-coupled motors by Brown-Boveri and Westinghouse. The geared motors have four poles, the direct-coupled six. The ratio of reduction is 1:3. There are four motors on each locomotive, two on each bogie. The motors are all mounted rigidly on the truck, with a spring coupling to the axle. The armature or the gear is mounted on a hollow shaft encircling the axle; the coupling consists of six spiral springs connecting the spokes of the car wheel with a star on the end of the hollow shaft. The Westinghouse brakes are supplied by a Christiansen compresser, driven by a motor with automatic switch. A certain number of motor cars and trains on the multiple unit system are in use. G. H. B.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

418. *Modern Electric Railway Practice.* **A. H. Armstrong.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 629-641, Aug.–Sept., 1901.)—Mountain railways, and high-speed passenger or freight trains which run long distances without stopping, offer, in the author's opinion, a field for the use of induction motors. In all other cases he prefers to employ continuous-current 500-volt motors, supplied through converter substations from an alternating system. Where a growing neighbourhood has to draw its supply of power for electric tram-cars from a continuous-current supply station, he advises the use of rotary converters fed from the station bus-bars, and supplying alternating current to the substations through step-up and step-down transformers. These converters may be transferred to substations when the growth has reached the point which warrants the installation of alternate-current generators. On elevated or underground railways with heavy trains and frequent stoppages, the motors must be capable of efficient acceleration with very high torque, and must not overheat to an unsafe degree from repeated temporary overloading, while the controlling apparatus must provide for their

[1] Non-Electrical Automobiles are described in the section dealing with steam and gas engines.

efficient handling during fractional speed running. These requirements all point to the use of continuous-current motors. They can give a torque much in excess of any service demand without sacrificing their running qualities at light loads, while induction motors can meet these infrequent overload demands only by the sacrifice of some of their advantages for normal operation. Comparing the average acceleration efficiencies for the frequency of stoppages usual on American elevated railways, the author estimates them at over 70 per cent. for continuous-current series motors, with the ordinary series parallel controller, and from 40 to 45 per cent. with induction motors. In the former case the acceleration efficiency may be slightly increased by the use of a series parallel controller provided for starting with four motors in series, changing first to two in series, and then to all in multiple; he does not, however, consider that the gain of 1 or 2 per cent. in efficiency warrants the increased complication. In the case of an infrequent service of trains, the elimination of attendance at the substations, when induction motors are used, is an important point in their favour, but, when there is a frequent service, the substations can be served by officials whose presence is required for other purposes. He suggests that track lines with heavy freight trains or high-speed passenger trains, as well as a local passenger traffic, might with advantage equip their tracks with both high-pressure overhead trolley for the operation of heavy through trains and freight work, and also use a third-rail construction to operate continuous-current 600-volt motors for the local work. He observes that both these systems could be fed from the same generator and transmission lines, operating 25-cycle rotary converters to feed the third-rail system at intervals, and step-down transformers to reduce the pressure to the 3,000 volts or more, required for the overhead high-pressure trolley line.

G. W. DE T.

419. *Electric Railway Apparatus.* **E. J. Berg.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 643–670, Aug.–Sept., 1901.)—In this paper the author discusses the characteristics in American practice of the various apparatus and their limitations, which latter really decide the choice of system. *Continuous-Current Generators.*—These are usually direct driven, and of frequency varying from 6 up to 15 or 18 cycles, and in some cases as high as 25, *e.g.*, in the case of "double-current generators." In these latter the compounding on the continuous-current side is of the ordinary character, and that on the alternate-current side is by phase control, viz., the load, consisting usually of rotary converters, is made to take leading or lagging currents which react on the machine, and thereby raise or lower the voltage according to the demand.

To accomplish this satisfactorily, the armature reaction should be fairly high, which involves not too close regulation. He observes that it has been customary to ask for a regulation as close as 6 per cent., attempting no phase control, but allowing the voltage to drop slightly with the load, although the requisite armature reaction, which is usually less than that of standard continuous-current practice, is not objectionable from the continuous-current generator point of view, since the voltage is regulated by the series field. *Alternate-Current Generators.*—These are almost invariably direct driven and having a frequency of 25 cycles, unless for lighting as well as traction work. They are usually designed for a regulation of from 6 to 10 per cent. In European practice polar windings are generally used to facilitate parallel running, but the American practice is to employ machines with high armature reaction, and rely upon flywheel capacity and efficient governing.

They are always of the revolving field type, and usually installed in connection with independent flywheels. The author ascribes the general European practice of making the armature of such a great flywheel capacity as to combine the flywheel and armature in one structure, to the higher frequency employed, making the diameter of the revolving field large enough to render it available as a flywheel. Machine-wound coils in open slots are used, the sine-wave form being approximated to as nearly as possible by suitably shaping the poles and slots. Automatic compounding is restricted to the smaller sizes, large direct-driven alternators for railway work being always hand-controlled, and the fields have only one winding. *Inverted Converters.*—These are decidedly more efficient than boosters, and are coming largely into use. Their constants are essentially those of continuous-current machines working at 25 cycles. Inverted converters are larger and more expensive than straight converters, on account of the lower armature reaction requisite to close speed control and to counteract the tendency to run away in case of a load of considerable magnitude, a low power-factor being suddenly thrown on. Even so, however, speed-limiting devices should not be omitted. As the voltage must then usually drop with the load, compensation is obtained by compounding the converter proper, and inserting reactances in the leads so that the rise of voltage can be obtained across them instead of at the inverted converter. When run in parallel with alternators, their naturally uniform rate of rotation makes it necessary to give special attention to the speed regulation of the prime mover, in order to avoid cross currents. *Rotary Converters.*—Except for "hunting" troubles these would, in the author's opinion, be more usually employed in preference to motor-generators. Speed variation in the prime mover as a cause of hunting is not serious in the case of the best made engines, and turbines eliminate it entirely. Other causes are (1) high resistance between different converters on the same network; (2) sluggish magnetic circuits in the converters; (3) occasional fluctuations in the impressed voltage. To meet (1) and (2) the magnetic circuit may be largely made up of cast iron, which has a high ohmic resistance, and damping devices may be inserted, not in the path of the main flux, but midway between the poles. Case (3) may preclude the use of rotary converters when, *e.g.*, a fluctuating load is placed near the position they should occupy, and is such as would give rise to considerable periodic pulsations in the converter circuit. Matters may, however, often be improved by the use of one or more large induction motors on the circuit, or even of a small induction motor with a large flywheel. When several rotary converters are operated in the same station, it is advisable to use independent transformers, or at least transformers with independent secondaries, to obviate cross currents in case of any relative difference in the position of the continuous-current brushes on the different converters. *Motor Generators.*—With an induction motor as driver a high stability is obtained, and such a set may be employed in systems of unstable frequency and fluctuating voltage, or when many synchronous motors are in use. Otherwise the author considers that it is most economical to design the transmission system so as to allow of the use of rotary converters. *Railway Motors.*—The relative advantages of continuous- and alternating-current motors are discussed in considerable detail, and figures and curves given, *based on assumed data,* illustrating the working of a town railway line with heavy traffic on the standard continuous-current system with series parallel control of the motors, and on the three-phase induction motor system, with rheostatic control, and with concatenated control in accelerating as well as braking. The conclusions arrived at are practically identical with those in the paper considered in the preceding Abstract. G. W. DE T.

420. *Steel-Rail Specifications.* **E. F. Kenney.** (Eng. News, 46. pp. 226–227, Oct. 3, 1901.)—It is desirable to keep the percentage of phosphorus very low, but in most mills this is impossible. Where the phosphorus can be kept below 0·06 per cent., the carbon can be raised to about 0·6 per cent. without danger of brittleness. With higher phosphorus (up to 0·1 per cent., which should be the limit allowed) the carbon must be kept to about 0·45 per cent. A Bessemer steel rail containing 3 per cent. nickel, 0·5 per cent. carbon, and 0·094 phosphorus is outlasting ordinary rails on a heavy curve, and will be eventually economical. A minimum size of ingot should be specified, according to the weight of the rail, because the more work done in blooming the better. The average reduction per pass in the blooming of American mills varies from 12 to 24 per cent., and the product is much superior in the latter case. Heavy work maintains the temperature and admits of starting the ingot at a lower and therefore better temperature. The average cropping from rail steel amounts to about 5 per cent. at each end; no attempt is made to crop off the zone of greatest segregation, as is done in making axle steel. The author considers that it would be economical to insist upon greater cropping, and pay the additional cost. Test analyses are usually made on small samples cast direct from the ladle: these cool too rapidly to permit segregation, and cannot be taken as fair samples in this respect. For instance, a rail from a heat whose sample showed C 0·45, P 0·09, S 0·076, Mn 0·93 fractured, and it was found that the analysis at the point of fracture was C 0·61, P 0·20, S 0·22, Mn 1·03. Microphotographs show that a much finer structure results from colder rolling than has been usual, even if it is only the final pass that is colder. The most practical way to fix the finishing temperature is by the length allowed for shrinkage. Many rails are damaged in the straightening presses by being strained beyond the elastic limit at each blow of the gag. [The article appears to be based on the author's work as Engineer of Tests, Pennsylvania Railroad, Philadelphia.] E. H. C.-H.

421. *Trolley Lines without Rails.* **M. Schiemann.** (Elektrotechn. Zeitschr. 22. pp. 964–967, Nov. 21, 1901.)—As against £4,000 to £5,000 per km. of trolley lines on rails, including the power station, a railless trolley line costs only £1,000 to £1,250 per km., exclusive of the power station. In July, 1901, a railless service with double overhead trolley line, equipped by Siemens and Halske, was started between Königstun and Königsbrunn in the Bielathal. The 24-passenger cars resemble ordinary omnibuses, and run at 12 km. per hour. Goods vans are run at 10 km. per hour. The overhead equipment is similar to ordinary trolley lines, but simpler, no frogs or crossings being provided. When two cars meet, one lifts its trolleys off. The trolleys are on the Dickinson principle, but have special lubricated contact shoes instead of wheels, which would not allow of sufficient side motion. The cars are driven through 8 : 1 spur gearings by a motor on each back wheel. Series-parallel control is used, with short-circuited electric brake. The fore-carriage turns on rollers to facilitate steering. The route has a continuous grade of 2½ per cent., and is full of curves, but the road surface is very good. The traction coefficient of the cars on the level road is 25 to 30 kg. per ton, *i.e.*, about double the figure for cars on rails. A railless line is essentially for light traffic, and this extra cost of operation is more than balanced by the saving in capital cost over a tramway on rails. A considerable advantage is that each factory can run out wires, and thus have goods delivered cheaply at its doors without transhipment. The results are more favourable than had been anticipated. E. H. C.-H.

422. *Rapid Transit in London.* **F. J. Sprague.** (Eng. Mag. 22. pp. 1–23, Oct., 1901.)—The author considers that rapid transit in London and its suburbs demands the widespread and radical application of electricity, with the construction of new tunnels built, according to a definite system, under the control of a single central authority, and forming a network following main arteries of traffic and connecting busy centres with each other and with outlying districts and suburban stations. The whole system should not only be constructed but worked under a single management. Classes should be abolished, one regular rate of fare established, with workmen's fares within limited hours, and there should be free exchange except on limited routes. Locomotive practice should be abolished, and trains operated in small units which could be combined at will. Electric tramways should replace many of the omnibus lines on crowded streets, and radiate from every terminus of tubular railways, and from most of the suburban stations. Every steam railway should equip at least its suburban service with electricity on a plan which permits of variable train lengths, plural control, high schedule speeds, and the maximum use of the existing permanent way. Maps are given showing existing railways and suggested additions needed to complete a harmonious comprehensive plan. G. W. DE T.

423. *Aluminothermic Process for Welding with Automatic Tapping.* **H. Goldschmidt.** (Zeitschr. Elektrochem. 7. pp. 935–943, Oct. 17, 1901.)—This is a further development of the Goldschmidt welding process [see Abstract No. 1200 (1900)]. The improvements mainly consist in the employment of a funnel-shaped crucible, having an aperture at the bottom closed by means of a small iron plate. The "thermite," a mixture of iron oxide and finely divided aluminium, is charged into this crucible, ignited, and the fused iron thus produced finds its way through the hole in the crucible into the mould surrounding the object, for instance, rails to be welded together. The operation, being thus entirely under the control of the operator, is easily performed. The tapping of the crucible may also be performed by means of a lever arrangement having a pointed iron rod for the purpose of clearing the discharge hole before pouring. The crucible, consisting of a funnel-shaped sheet-iron casing, has to be relined with a special refractory lining after from 5 to 10 "heats": a more recent improvement is the employment of a magnesia lining for the lower portion of the crucible, which part is subject to the greatest wear and tear. Ferro compounds of titanium and manganese can also be produced by mixing the respective oxides or metals. Various examples of the use the process may be put to are then given, such as, for instance, the joining of two square pieces of iron 100 by 100 mm. by means of a flange. Particular attention is drawn to the joining of steel rails, explained by a very clear drawing.

Various testimonials from railway engineers are cited, proving the excellence and strength of the welded joints. The repairing of broken propeller shafts is further mentioned, which is of very easy application, as, for instance, the work carried out by Messrs. Lester and Perkins at the Royal Albert Docks, London. O. J. S.

TELEGRAPHY AND TELEPHONY.

424. *Multiple Switchboard for the Berlin Telephone System.* **P. Krösing.** (Elektrotechn. Zeitschr. 22. pp. 909–912, Oct. 31; 928–934, Nov. 7; and pp. 947–953, Nov. 14, 1901.)—Some of the features of this board, which is by Siemens and Halske, are the following:—An exceptionally large capacity, obtained by arranging each 20 jacks in two rows of 10 each on a strip of hard rubber fixed at right angles to the longitudinal direction of the table. A reduction in the number of handles required in working the system is obtained by the introduction of call-indicating jacks, an improved form of speaking, or table, switch, and an improved ring-off indicator and polarisation cells. The call-indicating jack consists of a jack combined with a call-indicator to form one apparatus. The call-indicator, when actuated, is visible as a white pin in the shell of the jack. By introducing the hollow plug into the jack the circuit is made to the calling apparatus, and at the same time the call-indicator is returned to its position of rest. The forward motion of the call-indicating pin is produced by means of a spring released by the action of the calling current on an electromagnet arranged within the shell of the jack, the permanently magnetised core of this electromagnet holding the spring pin when in its normal position. The speaking, or table, switch requires no handle for calling and testing the connection made, since the lever, which is brought into the speaking-through position by pressing on a knob, is automatically returned to its normal position on breaking the connection. A lead weight suspended on the cord then comes into action and pulls the lever of the speaking, or table, switch into the position of rest, for which purpose the cord is connected by a chain to this lever. From the speaking-through position, by a further pressure on the knob, the switch can be brought into the hearing position, the lever, on ceasing the pressure, returning to the speaking-through position. Testing of the connections at the close of the conversation is not necessary, since the ring-off indicator in the circuit is actuated as soon as the first subscriber has replaced his receiver on the hook. This cuts out of circuit the polarisation cells, which are mounted on the speaking apparatus, which cells previously shut off the continuous current in the point connection of the plug from a ring-off indicator battery at the exchange, so that the current for the ring-off indicator is allowed to flow. Full details and drawings of all the apparatus and circuits are given. C. K. F.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

MARCH 1902.

GENERAL PHYSICS.

425. *Slide-rule.* **R. Proell.** (Zeitschr. Instrumentenk., Beib. 22. pp. 213–215, Nov. 15, 1901.)—The common objection to a long slide-rule is its unwieldiness; the objection to a short one is lack of precision. It is here shown that the logarithmic scale can be arranged in what is called "table form," *i.e.*, in a number of parallel lines of equal length, equally spaced with respect to one another, drawn from the same straight line. Using ten of these lines, the author obtains, within convenient dimensions, a logarithmic scale of 1·20 metres. Two such "tables" are used in combination, an upper and a lower; the logarithmic scale in one beginning from left to right, and in the other from right to left. With this arrangement great accuracy is claimed; square-roots and cube-roots are said to be obtained easily to four decimal places. R. A.

426. *Balance Immersed in Water.* **G. Guglielmo.** (Accad. Lincei, Atti, 10. pp. 259–268, Dec. 1, 1901.)—The paper describes the construction and theory of a balance used under water to determine densities. As the weight of the balance in water can be made extremely small, the friction on the knife-edges is small, and these are, moreover, lubricated by the water. On this account the balance can be made far more sensitive than the ordinary balance, and in determinations of density the error due to surface tension on the suspending wire is avoided. The construction shown is very simple; the balance arm is made of glass, with a central bulb of such a size as to give the whole balance a suitable weight. The knife-edges of the ordinary balance are replaced by points resting on planes. G. H. B.

427. *Recording Rain-gauge.* **P. Lancetta.** (Elettricità, Milan, 20. pp. 775–777, Dec. 7, 1901.)—Between the funnel and receiver of an ordinary rain-gauge is fixed a chamber containing a little water-wheel with six buckets. The water from the funnel drops into one bucket, which, when full, slips past a spring catch; the next bucket then takes its place. The axis of the wheel carries a disc with six contact pieces, so that every time a bucket is filled an electric contact is made, and a mark registered on a chronometer tape.

G. H. B.

428. *Nitrometer.* **G. Oddo.** (Accad. Lincei, Atti, 10. pp. 268-269, Dec. 1, 1901.)—In determining the quantity of nitrogen in organic substances, the method of freeing the combustion tube of air by carbonic anhydride, and collecting the nitrogen in Schiff's nitrometer, gives results somewhat too high. On the other hand, the method employing a vacuum pump and concentrated potash solution, though more exact, is troublesome and lengthy. The author has so modified Schiff's nitrometer that it can be applied to a Sprengel pump, and thereby combines the advantages of the two methods. The nitrometer consists of a graduated tube, closed at the bottom, and with a tap at the top. Near the bottom are three side tubes, one is for attaching to the pump, and serves for the introduction of mercury and gas, the second is for withdrawing the mercury, and the third is for the potash solution.

G. H. B.

429. *Tachometry.* **J. A. Fleming.** (Cassier, 21. pp. 37–40, Nov., 1901.) —In addition to general remarks on the subject, and a short account of the stroboscopic method, the author strongly advocates the employment of a hydraulic speed indicator which is in use in his laboratory. A small, circular, centrifugal pump, consisting of a four-bladed brass fan, with blades parallel to the fan shaft, enclosed in a cylindrical brass case, just clearing the blades, has its fan shaft geared to the wheel or shaft whose angular velocity is to be recorded. The pump chamber communicates, through an opening near the shaft, with a reservoir of water, and, through an opening in the cylindrical surface, with a vertical glass tube. The height of the liquid in the tube will then be proportional to the square of the angular velocity to be determined. The fan shaft glands require packing watertight against a very slight pressure only, and the arrangement is very sensitive. Moreover, the greater the speed, the greater will be the actual variation in height in the column of liquid corresponding to a given percentage variation in the speed. It also has the advantage that the glass gauge tube need not be near the pump. For example, if used for electric machinery, the gauges may be affixed to the switchboard. The author has found it possible, by means of this arrangement, to control the speed of alternators to within a quarter of 1 per cent.

G. W. DE T.

430. *Resistance to Motion in Fluids.* **F. Ahlborn.** (Phys. Zeitschr. 3, pp. 120–124 ; Discussion, p. 124, Dec. 15, 1901. Paper read before the 73rd Naturforscherversammlung at Hamburg, 1901.)—The author attaches one or several plates under various angles to a carriage, driven by an electric motor, regulated by a flywheel and electric and mechanical resistances, through a trough filled with water into which lycopodium seed or sawdust is being strewn. A camera is fixed on the carriage, and is moving with the plate, so that the flashlight photographs show the plate stationary and the water in motion. The plates were either dipping into the water, in which case the surface tension has to be overcome, or totally immersed in the water ; in the latter case mirrors were inserted in the sides and bottom of the trough. Practically the same stream line diagrams resulted in both cases. The author then coloured the water and lowered and raised the cardboard plates while in motion. In this way he obtained profile diagrams of the rise and fall of the water in front and rear of the plate. The front wave is flat, but falls off towards the edges without reaching the zero line ; the rear wave is a kind of lemniscate. The author makes relief models of these waves. All these

phenomena are in close analogy with observations made in air by L. Mach, Marey, and Recknagel.—The discussion by **König** and **Grimsehl** concerned the agreement of the experiments with Rayleigh's formulæ. H. B.

431. *Attraction to a Vibrating Surface.* **R. Geigel.** (Ann. d. Physik, 6. 4. pp. 856–860, Dec. 5, 1901.)—In an electroscope in which a leaf of metal-foil hangs on each side of a brass plate connected with the knob, the author noticed that when the knob was tapped the two leaves were attracted to, and held against, the brass plate, and fell back free after a few seconds. The particle describes experiments made to ascertain the cause of this phenomenon. In a vacuum it does not occur, and depends, therefore, on some action of the air. The same phenomenon was observed by holding a strip of paper near one prong of a vibrating tuning-fork; the paper fell away while the fundamental note was still audible. Lycopodium sprinkled on the prong gathered itself into spheres, which were not thrown off the fork, but kept up a very active and rapid motion for a certain time, and then settled down into discs. Their motion ceased after the same length of time, during which a paper strip was attracted to the prong, and the author concludes that both phenomena are due to the same cause, namely, to very rapid vibrations, which, from the distance separating the lycopodium spheres, he estimates at 32,250 per second. G. H. B.

432. *Optical Methods of Observing Diffusion.* **J. Thovert.** (Comptes Rendus, 133. pp. 1197–1199, Dec. 23, 1901.)—Observations of the deviations of horizontal beams of light in diffusing solutions at different levels and at different times give the values of k, the coefficient of diffusion. If c be the concentration, x the level, h the whole height of the column, and n a whole number,

$$\frac{dc}{dx} = \sum_{n=1}^{n=\infty} A_n \sin \frac{n\pi x}{h^2} \varepsilon^{-\frac{n^2\pi^2}{h^2} kt}$$

When t is long enough, dc/dx varies sensibly with $\sin \frac{\pi x}{h}$ at a given time, and with $\varepsilon^{-\frac{\pi^2}{h^2} kt}$ at a given level; this occurs in, say, 72 hours. Observations at one level at times t_1, t_2, thereafter give deviations Δ_1, Δ_2, such that—

$$k = \frac{h^2}{a^2} \frac{\log \Delta_1 - \log \Delta_2}{t_1 - t_2}$$

If the solution and the distilled water each occupy exactly one-half the column, the even terms in the value of dc/dx disappear; and at the level $\frac{1}{3}h$ or the level $2h/3$ the third term also disappears; so that at these levels the condition favourable as above to the estimation of k is very rapidly attained. If in this case the deviations be observed at levels $h/6$, $h/3$, and $h/2$, the sum $\Delta_{h/6} + \sqrt{3}\Delta_{h/3} - \Delta_{h/2}$ is proportional to $\varepsilon^{-\pi^2 kt/h^2}$ from the outset; so that the required observations at two times, t_1 and t_2, may be speedily secured. A. D.

433. *On some Problems of Elastic Equilibrium.* **O. Tedone.** (Accad. Lincei, Atti, 10. pp. 251–258, Dec. 1, 1901.)—The author imagines an elastic solid bounded by that part of the plane of $\eta\zeta$ which contains positive ζ (the plane σ_1), and part of the plane of $\xi\eta$ which contains positive ξ (the plane σ_2). Suppose four points, A, A_1, A_2, A_3, forming a square whose sides are parallel

to ζ and ξ, and of which A is the point ξ, η, ζ, and A_3 is $\xi, \eta, -\zeta$. He takes r, r_1, r_2, r_3 as the distances of any point from A, A_1, A_2, A_3 respectively. The displacements of any point in the solid are u, v, w, and are supposed to have given values on the planes σ_1 and σ_2. The problem then is to determine u, v, w at any point in the solid. He obtains the general equations of equilibrium in the form—

$$\Delta^2 u = -\frac{\lambda+\mu}{\mu}\frac{\partial\theta}{\partial\xi}, \quad \Delta^2 v = -\frac{\lambda+\mu}{\mu}\frac{\partial\theta}{\partial\eta}, \quad \Delta^2 w = -\frac{\lambda+\mu}{\mu}\frac{\partial\theta}{\partial\zeta},$$

where λ and μ are Lamé's constants, and—

$$\theta = \frac{\partial u}{\partial\xi} + \frac{\partial v}{\partial\eta} + \frac{\partial w}{\partial\zeta}.$$

Hence, using functions of the form $(1/r - 1/r_3)$, &c., and by the application of Green's and analogous theorems, u, v, w at ξ, η, ζ are determined in terms of the given values of u, v, w on the planes σ_1 and σ_2. It is impossible to represent the work, which is purely mathematical, adequately in an abstract. S. H. B.

434. *Viscosity of Solutions Containing only Organic Substances.* **C. Schall.** (Phys. Zeitschr. 3. pp. 62–63, Nov. 15, 1901.)—Measurement made to test a formula of G. Jäger's (Wien. Akad. Ber. B. CIII. Abt. IIa, 245). As solvents aqueous glycerine and thymol were used. F. G. D.

435. *Relative Determinations of Gravity.* 1. *Determinations at ten Stations on the Meridian of Tübingen.* **K. R. Koch.** (Zeitschr. Instrumentenk. 21. pp. 269–271, 1901. From the Jahreshefte d. Ver. f. Vaterländ. Naturkunde in Württemberg, p. 356, 1901.)—This paper deals with results for ten of the ninety gravity stations of Württemberg. The author describes pendulum experiments to determine the difference in the values of gravity at each of those ten stations, and its value at the base-station at Stuttgart. The stations lie on the same meridian. At the same time as an observation was being made at any station, a second observer took observations of a pendulum at Stuttgart, the two stations being electrically connected, so that the *same* chronometer (a Kutter precision-chronometer) served for both. This obviated the necessity for determining the rate of the chronometer. A special support devised by the author and possessing exceedingly great rigidity was used, and the temperature constants of the pendulums employed were carefully determined. A table of results gives the latitude of each station, the latitude of the base-station at Stuttgart, and the excess of the observed value of gravity over its calculated value for all the stations. This excess increases from 0·01 cm. per sec. per sec. at Bitz (latitude 48° 10′ 30″) to 0·07 cm. per sec. per sec. at Fürfeld (latitude 49° 12′ 35″). The mean longitude of the stations is 9° 5′ east of Greenwich. W. S.

436. *Thermoelectric Determination of Underground Temperatures at the Museum of Natural History.* **H. Becquerel.** (Comptes Rendus, 133. pp. 800–803, Nov. 18, 1901.)—One junction, B, of an iron-copper circuit which includes a Deprez-d'Arsonval galvanometer, is exposed to the unknown temperature; the other junction, A, may be at any constant known temperature, t_0—not conveniently at 0° as in the A. C. Becquerel arrangement of 1826. The scale of the galvanometer is calibrated so that temperatures corresponding to currents may be read off directly. The circuit being

open, the scale is now moved parallel to itself so that the zero of the galvanometer coincides with the figure indicating the temperature t_0. On closing the circuit, the beam of light is thrown on to the figure which marks the temperature of the junction B. D. H.-J.

437. *Heat Exchange in the Soil, the Water, and the Atmosphere.* **J. Schubert.** (Phys. Zeitschr. 3. pp. 117–119, Dec. 15, 1901. Paper read before the 73rd Naturforscherversammlung at Hamburg, 1901.)—The author makes use of observations covering different periods, made by himself in different soils at Eberswalde; by Homén in Finland; by Petterson on the East Sea (maximum depth 55 m.) and North Sea (200 m.); at the Danish lighthouse stations, in the Hintersee in Prussia, and in the balloon ascents from Paris, after Hann. Though the data are uncertain, they show that the Baltic takes up, per unit area, during summer, from twenty to thirty times, and the North Sea thirty to forty times as much heat as the firm land, and that the heat exchange in the atmosphere is (at Paris) 3/2 times that of sandy soil, 1/15 that of the Baltic, and 1/25 of the North Sea. In the case of water we have not only to consider heat capacity and evaporation. This is apparent from the behaviour of wet moors and sand. Wet moors have a high heat capacity, almost as high as water, and evaporate much more water than sandy soil, the wet surface becoming very warm; but the heat does not penetrate deep, and the moor takes up less heat than sand. In open water the temperature fluctuations penetrate to great depths; in the Kattegat the yearly temperature variation is still 8° at a depth of 26 m. Firm soil becomes hot on warm days and in warm seasons, and gives off much heat to the air, but it stores up little heat and cools rapidly. The sea stores up the heat; its surface does not get hot, little heat is imparted to the air, and the heat is replenished from the depth during the cold season. The temperature maximum and minimum respectively of the soil are in September and March, of the air and water in August and February. The maximum heat absorption occurs in May (soil and air) or June (water), the maximum heat loss in October or November, when the surface of the sea is about 2° warmer than the air above it; the yearly mean excess of the temperature of the sea surface over that of the air amounts to more than 0·5°. H. B.

438. *Metcorological Observations with Kites at Sea.* **A. L. Rotch.** (Science, 14. pp. 896–897, Dec. 6, 1901.)—While crossing the Atlantic from Boston to Liverpool, the author could fly kites on five out of eight days, and obtained records of the atmospheric pressure, temperature, humidity, and wind velocity for heights up to 2,000 feet. The temperature fell rapidly over the sea with increasing height; otherwise the records were not remarkable. The author hopes that kites will be used on steamers which would create sufficient wind even in calms, especially in the tropics, where we have no observatories, and for the exploration of the trade winds. He quotes Hildebrandson in his support, who would fit the steamers also with balloons. H. B.

439. *Mean and Normal Meteorological Values.* **E. v. Rijckevorsel.** (Archives Néerlandaises, 6. pp. 367–370, 1901.)—The author shows that it would hardly be possible to obtain normal meteorological values directly by taking means, even if we had statistics covering thousands of years at our disposal. For exemplification of this he gives series of temperature, barometer, and sun-spot observations for periods of various lengths, 31, 30, 20, 10, 5 days. H. B.

440. *Transparency of the Air from Observations of Distant Objects.* **E. Oddone.** (N. Cimento, 5. pp. 264–268, Oct., 1901. Rend. del R. Ist. Lomb. di Sc. e Lett, Ser. 2, 34, p. 24, 1901.)—Previous observations have been made either for distances of a few metres or for the height of the atmosphere. The author has endeavoured to fill the gap. His method was to compare (indirectly) the brightness of the snow on distant Alpine peaks with that of snow near at hand, each being directly compared with a white metal plate. He chose times when the peaks appeared nearly identical in brightness with the background of sky against which they were seen, a precaution necessary in order to obtain a sufficiently large field of view in the photometer (a Bouguer photometer, with blackened draw-tubes, adjustable in altitude and azimuth). When there was doubt as to the actual visibility of the peak, this was tested by employing a Nichol prism to cut off the polarised light of the sky, and thus allow the peak to show up by contrast. Lambert's law of illumination was assumed in calculating the results. The following values were obtained for the mean coefficient of transmission per km.:—

Date.	Snow Peak Observed.	Distance in km.	Coefficient.
Feb. 14 and 16	Monte Penice .....(1462^m)	45	$0{\cdot}95_5$
Jan. 1, March 4.....	M. Grigna, north ...(2410^m)	85	$0{\cdot}98_8$
March 4	M. Weissmies .....(4031^m)	134	$0{\cdot}99_5$

A. E.

441. *Antisolar Coronas at the Pûy de Dome.* **B. Brunhes.** (Comptes Rendus, 133. pp. 1204–1207, Dec. 23, 1901.)—Since October 2, 1901, four observations of antisolar coronas (Spectre of the Brocken) have been made by the author, and twenty by David at the observatory on the summit of the Pûy de Dome. The greatest number of rings seen was four, and the usual number three. The outer edge of each ring is red, and the inner generally green, except the inner part of the ring of least diameter, which is yellow. The internal and external diameters of the first and second rings were repeatedly measured, and exhibited considerable variations; these variations are shown to depend on the humidity of the air, the diameters of the rings decreasing with increase of moisture in the air, and therefore with increase in size of the drops of water which are the cause of these phenomena.

W. C. B.

442. *Two-foot Yerkes Reflecting Telescope.* **G. W. Ritchey.** (Astrophys. Journ. 14. pp. 217–233, Nov., 1901.)—The article contains a description of improvements adopted in the installation of the new reflector at the Yerkes Observatory, complete details as to subsidiary equipment for general and special investigations, and also a special design suggested for a proposed new reflector of 5 feet aperture. The performance of the 2-foot instrument is shown by two excellent reproductions from photographs of nebulæ. C. P. B.

443. *Solar Constant.* **F. W. Very.** (Monthly Weather Rev. 29. pp. 357–366, 1901.)—The author first summarises the difficulties involved in the determination of this important factor, the majority being due to the indirect methods of observation which are of necessity followed. In the

choice of instruments as simple arrangements as possible should be employed, as the theory of many of the complicated methods in present use is far from being definite. Passing over comparative descriptions of the chemical actinometer used by Vallot and of Paschen's repeating bolometer (specially recommended as accurate for spectral energy work), it is suggested that the first investigation going really to the root of the matter was that of Langley at Mount Whitney, by making a bolometric determination of the entire infra-red spectrum. This work leads directly to the important distinction between the two different kinds of selective depletion in operation, whereby the solar rays suffer in traversing the earth's atmosphere. Numerous references to the work of subsequent investigators are next given and discussed, the main cause of discrepancy appearing to arise from inadequate formulæ of reduction. The absorption must be separately allowed for under the two forms—(*a*) *band absorption*, chiefly taking place in the upper air at the longer wave-lengths, is quite local in its action, and including the greater part of the infra-red absorption of water-vapour ; (*b*) *selective reflection*, which acts chiefly in the lower atmosphere at short wave-lengths. The low layers of a moist atmosphere become heated because they absorb the rays of extremely long wave-lengths emitted by the heated soil. On these considerations the author states that most of the past reductions of actinometric measurements do not give the solar constant, but this quantity diminished by the band absorption which has escaped detection. A new reduction of the Mount Whitney observations gives the comparatively high value of 3·127 for the solar constant. [See further Abstract No. 344 (1901).] C. P. B.

444. *Variability of Earthshine.* **H. H. Kimball.** (Monthly Weather Rev. 29. pp. 209–211, 1901. Paper read before the Astronomical and Physical Society of Toronto, 1901.)—The author develops Bond's formula for reflected light by introducing terms representing the albedos of the earth and moon and the distance between these two bodies. In the observation of earthshine, which is due to the light reflected from the earth's surface, the chief factors are the distance and the albedo of the earth. The main causes of variation in the latter are : (1) The distribution of land and water surfaces on the hemisphere illuminated by the sun ; (2) the extent of the hemisphere enveloped in clouds ; (3) the variation in character of the cloudy area, and the presence or absence of snow.

Bond, Herschel, and Zöllner have measured the relative albedos of various rock surfaces, water, &c., compared with white paper at various angles of incidence. In the case of the other factor, the variation in distance from 221,000 miles at perigee to 253,000 miles at apogee may introduce as much as 50 per cent. alteration in the intensity of the earthshine, and it is concluded that the variation observed is mainly due to this factor. C. P. B.

445. *The Annular Eclipse of the Sun on November* 10, 1901. **A. de la Baume-Pluvinel.** (Comptes Rendus, 133. pp. 1180–1185, Dec. 23, 1901.)—A series of visual and photographic observations of the eclipse carried out in Cairo under very fair atmospheric conditions. Before and after the annular phase several photographs of the sun's spectrum close to the moon's disc were taken, the edge of the moon being tangential to the slit. These photographs were examined very carefully, and showed no trace of any change in the Fraunhofer lines close to the moon's edge, which is a further proof of the non-existence of a lunar atmosphere. This was also borne out by visual observation of the spectrum between D and *a*.

A photograph was also taken of the spectrum of the crescent of the chromosphere which appears just before the second contact. This shows 49 rays whose wave-lengths are given, and of these 14 have not been before observed. Amongst the remainder those due to hydrogen and the H and K calcium lines are very intense.

Another photograph was taken, immediately after the second contact, of the spectrum of the narrow segment of the sun's surface. It was found that the hydrogen lines were quite absent—a fact which the author explains by considering that the bright hydrogen spectrum of the chromosphere balances the effect of the absorption due to the photosphere. This, however, is not the case with the H and K calcium lines. Photographs taken of the sun in the middle of the eclipse showed no trace of the corona.

A laudatory note on the above is added by J. Janssen. E. C. C. B.

446. *Temperature and Composition of Planetary Atmospheres.* **E. Rogovsky.** (Astrophys. Journ. 14. pp. 234–260, Nov., 1901. Revised and translated by the author from Transactions of the Russian Astronomical Society, Part 7, pp. 10–34, 1898, and Part 8, pp. 32–45, 1899.)—The paper contains an analysis of the results obtained by various methods involving different laws of radiation. Tables are given showing the probable relative temperatures and composition of the several planetary surroundings. The author concludes that the physical and chemical constitutions of the atmospheres of all the members of the solar system are in close relation, and that any variations in that of the central sun produce corresponding changes in the others, although a considerable interval may intervene between the two changes. C. P. B.

447. *Spectrum of Nova Persei.* **W. W. Campbell, W. H. Wright,** and **J. Stebbins.** (Astrophys. Journ. 14. pp. 269–293, Nov., 1901. From the Lick Observatory Bulletin, No. 8.)—The paper contains a complete account of the changes observed in the spectrum of Nova Persei as determined from photographs obtained at the Lick Observatory. Six plates of reproductions of the spectra at various stages are included, and tables of the measured wave-lengths of the lines found on the photographs. C. P. B.

448. *Changes in the Nebulosity around Nova Persei.* **G. W. Ritchey.** (Astrophys. Journ. 14. pp. 293–294, Nov., 1901.)—Photographs obtained with a 2-foot silver-on-glass reflector at the Yerkes Observatory showed distinct evidences of changes in the form of many of the principal condensations in the nebulosity surrounding the new star in Perseus. Exposures varying from one to seven hours were given, and the plates carefully measured. Four of these photographs are reproduced, and the changes described are clearly visible. It is not yet known whether these changes are due to an actual translatory motion of some definite portion of matter, or whether successive portions of an extensive area of nebulous matter are rendered luminous by disturbances at different times. C. P. B.

REFERENCE.

449. *Cavendish Apparatus.* **M. Kohl.** (Ann. d. Physik, 6. 3. pp. 641–645, Nov., 1901.)—A convenient and transportable form of apparatus is described for Cavendish's experiment on the mutual gravitation of two masses. A. D.

LIGHT.

450. *New Form of Radiometer.* **F. A. Saunders.** (Astrophys. Journ. 14. pp. 136–137, 1901.)—The author describes a new form of case for the radiometer described by E. F. Nichols (Wiedemann's Annalen, 60, 401, 1897). The advantages of the present form are as follows: The apparatus is practically airtight, requiring exhaustion only about once a month. Tinfoil strips in connection with the case project into the interior and dissipate any electric charges in an hour or two after exhaustion. The system may be turned about a vertical axis without altering the pressure within the tube, and so the zero-point may be adjusted. Finally, the instrument is very sensitive, cheap, and easy of adjustment. W. S.

451. *Determination of Crystalline Systems of Microscopical Crystals.* **J. L. C. Schroeder van der Kolk.** (Archives Néerlandaises, 4. pp. 341–345, 1901. Translated from Zeitschr. f. Wiss. Mikrosk. 12. pp. 188–192, 1895.)—Certain practical difficulties are met with in the above determination by means of the polarising microscope, *e.g.*, it is not always possible to distinguish between uniaxial and biaxial crystalline needles. By means of a hemisphere of glass whose convex side is introduced into the circular opening of the microscope table, and whose plane side serves to hold the object, the following motions of the crystalline needle are attained: (1) Round its axis, (2) round the horizontal normal to the axis, (3) round these two in succession, (4) round the vertical. By these means, it is possible to distinguish several cases that would be otherwise ambiguous or difficult. Illustrations are given for several systems. J. W. P.

452. *Reflecting Power of Metals for Ultra-Violet Rays.* **E. Hagen** and **H. Rubens.** (Deutsch. Phys. Gesell., Verh. 3. 13. pp. 165–176, 1901. Communicated by the Physikalisch-Technischen Reichsanstalt.)—The rays are examined by means of a linear thermo-couple which replaces the eye-piece of a spectrometer. The source of the ray is the positive crater of an arc lamp. Besides the already known bands in the ultra-violet, the authors found three others with intensity maxima of wave-lengths 305, 288, and 251 $\mu\mu$ respectively. The rays are filtered through water, and focussed by quartz lenses on to a right-angled quartz prism, placed near the centre of curvature of the concave metal mirror examined. By use of the prism in two positions the rays can be reflected either to the mirror on one side or in the opposite direction through an achromatic combination which focusses them, or the rays from the mirror, on the slit of the spectrometer. The rays are thus examined before and after reflection. No glass is employed in the construction of the apparatus, except for a filter screen. The relative reflecting powers for wave-lengths varying from 500 to 251 $\mu\mu$ were measured, the numbers being reduced by means of values previously found [see Abstracts Nos. 992 (1899) and 463 (1900)] by an optical method. The numbers obtained for silver and gold by the two methods respectively are in good agreement. Nutting's results [see Abstract No. 285 (1902)] agree only approximately with those of the authors, and for silver alone. His method is considered unsuit-

able for quantitative measurements. The reflecting powers are in percentages of the incident radiation.

For λ =	251	288	305	316	326	338	357	385	420	450μμ
Fresh silver	34·1	21·2	9·1	4·2	14·6	55·5	74·5	81·4	86·6	(90·6) 90·4
Old silver	19·2	15·9	12·3	5·6	8·8	45·0	61·0	71·0	79·9	88·7
Platinum	33·8	38·8	39·8	—	41·4	—	43·4	45·4	51·8	(55·8) 54·2
Nickel	37·8	42·7	44·2	—	45·2	46·5	48·8	49·6	56·6	(56·5) 59·8
Steel (unhardened)	32·1	37·1	41·1	—	41·1	41·9	43·1	44·0	51·0	(56·3) 52·5
Gold	38·8	34·0	31·8	—	28·6	—	27·9	27·1	29·3	(36·8) 31·3
Copper	31·5	29·7	30·9	—	30·4	—	33·3	34·9	39·9	(48·8) 45·2
Rosse's alloy	29·9	37·7	41·7	—	—	—	51·0	53·1	56·4	(62·9) 58·5
Schroeder's alloy No. 1	40·1	48·4	49·8	—	54·3	—	56·6	60·0	62·2	(62·4) 62·7
Schroeder's alloy No. 6	39·2	42·7	44·7	—	50·1	—	53·0	55·3	59·6	(61·5) 60·4
Mach's magnalium 69 per cent. Al + 31 Mg	67·0	70·6	72·2	—	75·5	—	81·2	83·9	83·3	(83·4) 83·4
Brandes-Schünemann alloy	35·8	37·1	37·2	—	39·3	—	43·3	44·3	47·2	(49·1) 49·2

The numbers in brackets were found by the optical method. G. E. A.

453. *Photographed Gratings.* **G. Meslin.** (Journ. de Physique, 3. pp. 750–751, Dec., 1901.)—The author has succeeded in making gratings by photographing, on a bichromated gelatine plate, the bands produced by a narrow slit and a grating. The sensitive plate was placed in a small dark chamber fitted with a camera shutter, being developed, after several minutes' exposure, in tepid water. The photographs have been reproduced in other journals. G. E. A.

454. *Anomalous Dispersion of Sodium Vapour.* **R. W. Wood.** (Roy. Soc., Proc. 69. pp. 157–171, Dec. 24, 1901.)—An accurate study of the dispersion of a substance with absorption bands so narrow and strong as those of sodium vapour, should be of great value in testing the various dispersion formulæ. The author has, therefore, made experiments to determine whether sufficient data could be obtained. He has succeeded in forming a complete anomalous spectrum in which all the colours are present, except a range of some 20 Ångström units at the D lines. The first experiments were made with a large hollow prism of iron with glass windows. Great trouble was experienced from deposits on the glass, and as it was evident that the oblique faces played but a small part, the refraction being due almost wholly to the variation of density in the vapour, the prism form was given up, and a tube, preferably of sheet iron, about 30 cm. long, and 2 cm. wide, was adopted instead, having plate-glass ends, attached with sealing-wax, at such a distance from the heated vapour that no deposit occurred. Dry hydrogen is conducted into and out of the tube by two glass tubes passing through the wax. A piece of sodium having been inserted, the tube, placed horizontally, is heated by a Bunsen burner. In order to study the dispersion of the vapour, the light of an arc lamp is focussed on the *horizontal* slit of a collimator, and the parallel rays from the latter pass lengthwise through the dispersion tube. A second lens brings them to a focus on the *vertical* slit of

a spectroscope or, when desired, in the focal plane of an eyepiece. With the latter a superb spectrum is seen. A thin thread of violet occupies the centre. Next it is a wide dark band, due to the D absorption. Then comes a flare of red, fading off to orange. On the other side of the violet is blue, then a gap, corresponding to the fluted spectrum below, then a flare of green ranging on to yellow.

On spectroscopic examination, with the crossed slits above described, the spectrum appears as two oppositely curved branches, one on each side of D. The breadth of the D absorption band is sometimes 15 times the distance of the D lines. As the tube grows hotter, both branches grow out rapidly, and a beautiful fluted absorption appears in the red and greenish-blue, which finally blots out a region in the blue. Meanwhile the curvature increases remarkably, and the entire red end is lifted high above the blue end. In consequence of the rapid changes, the following method was adopted in measuring deviation: The telescope of the spectrometer was replaced by an objective of 2 m. focus, in whose focal plane a glass plate was mounted, with an eyepiece behind it. Positions could then be recorded by scratching on the glass. By making the dispersion tube the chamber of a radiophone, the author proved that much of the energy absorbed by the sodium vapour is spent in raising its temperature. The question is raised whether there is any lateral emission of light by sodium ions in resonant vibration. A way is described of producing a very satisfactory prismatic sodium flame by passing hydrogen through a tube containing strongly heated metallic sodium, and burning the gas at a flat jet piece made of platinum foil. Reproductions of photographic spectra are given, and also a striking coloured picture of the anomalous spectrum, as viewed directly. A. E.

455. *Anomalous Dispersion of Oxyhæmoglobin.* **L. Puccianti.** (N. Cimento, 5. pp. 257–264, Oct., 1901. From a paper read before the Società Italiana di Fisica, Bologna, Sept. 24, 1901.) — The absorption spectrum of oxyhæmoglobin presents two characteristic bands; one α, between yellow and green, extending from 0·589 μ to 0·570 μ, the other β between green and blue-green, extending from 0·550 μ to 0·530 μ. These bands are visible, even with a fairly thin layer of very dilute solution. The crossed prisms method being found not sufficiently sensitive, an interference method was adopted, Jamin's refractometer being used in conjunction with a spectrometer. The rays from the sun or an arc lamp, collected by a lens, fall at 45° on a thick glass plate. The reflected rays, after passing through the trough and a compensator, are again reflected at 45° by a second thick plate parallel to the first. Interference fringes are thus produced, of which a real image is formed on the slit of the spectrometer by means of an achromatic lens. The trough is divided transversely, one portion containing the solution, the other water. Rays reflected from the front of the first plate pass through one half, from the back through the other half. The field of the spectrometer is crossed by a series of alternate dark lines and narrow spectra, corresponding to the dark and bright interference bands. The spectra are sharpest in the red, and most diffuse in the absorption regions, the diffuseness increasing with the strength of the solution. Initially, the central dark line is brought to coincidence with a horizontal reference wire. As the strength of the solution is gradually increased, the bands are displaced, the whole series assuming an upward slant from red to violet, except in the two regions corresponding to the α and β absorption bands, where the slant is much less, or even reversed. If m be the number of black bands seen crossing the

horizontal wire, then $r = m\lambda$ gives the retardation. The index n is then obtained from the formula $n = 1 + r/ns$, n being the refractive index of water relative to air, and s the distance traversed in the solution. Curves are given showing the variation of retardation with wave-length for different concentrations. The drop at each absorption band, and rapid rise on approaching it, are very obvious. Commercial hæmoglobin was used in most of the experiments. A. E.

456. *Reversible Actions of Light.* **E. Goldstein.** (Deutsch. Phys. Gesell., Verh. 3. 14. pp. 182–188, 1901.)—The colours produced in glass by kathode rays are destroyed by ultra-violet light or by sunlight. The changes produced by ultra-violet light are reversed by waves of greater length. The colours can also be destroyed by heating. Silver chloride, enclosed in a tube and darkened by sunlight, will, in the dark, take up the liberated chlorine again and resume its original colour. In continuous light a condition of equilibrium is reached, the pressure of dissociated chlorine depending upon the brightness of the light. Bromide of silver blackened by kathode rays put in a closed tube (16 to 18 mm. wide) in the sunshine becomes in three-quarters of an hour of its original colour all through, except at the illuminated surface; in diffused light this result is reached in about two days (with AgCl some months are required). Bromide of silver prepared by dissolving AgCl in ammonia and adding KBr and HNO_3 is readily powdered; and if the ammonium nitrate have not been quite washed out of it, it is comparatively very insensitive to light, taking hours or days, instead of seconds, to darken, but is promptly darkened by kathode rays. If, however, the blackened powder is tilted in the tube out of the way of the kathode rays, the positive light of the discharge will regenerate it in a fraction of a minute; and, again, if the vacuum be varied so as to make the kathode discharge luminous, the blackening is immediately destroyed. Iodide of silver blackens and liberates iodine under kathode rays; a few days' daylight regenerates the yellow iodide; a few seconds under the positive light of the discharge will do the same if the blackened iodide be warmed. A. D.

457. *Induced Radio-activity.* **P. Curie** and **A. Debierne.** (Comptes Rendus, 133. pp. 931–934, Dec. 2, 1901.)—Various solid bodies acquire induced radio-activity when placed in a closed vessel with a radio-active salt of radium. The effects obtained are more regular and more intense when the radium salt is in the form of an aqueous solution. The induced radio-activity is independent of the pressure, and of the nature of the gas in the enclosure. Certain substances, those becoming phosphorescent on exposure to light, and certain others, become luminous when placed in an activating enclosure. If two glass globes be arranged, communicating by a bent tube, and in one a solution of an active barium salt containing a few milligrammes of radium, be put, and in the other a substance such as sulphide of zinc, the zinc sulphide becomes brightly luminous, as much so as when it has just been exposed to an intense light. The luminosity is due to the induced radio-activity communicated through the bent tube, and not to direct radiation from the radium. The intensity of the Becquerel radiation from the zinc sulphide in this experiment is exactly the same as that from a piece of copper or any other substance placed in the same conditions. The glass also becomes phosphorescent by induced radio-activity. The induced radio-activity of bodies placed in an activating enclosure depends essentially on the free space existing around them. An activating enclosure of glass is illuminated

entirely, but not equally throughout, the wider portions of the tube being more luminous and more radio-active. The final activity in an enclosure when the limiting value has been reached, perhaps after some weeks, depends only on the quantity of radium which has been introduced in the state of solution, but in a wide enclosure the active state is reached more rapidly. The activity increases in an enclosure when the quantity of activating solution is increased. The power of activation of a solution is thus not analogous to a vapour tension. J. J. S.

458. *Influence of Radio-active Substances on the Luminescence of Gases.* **A. de Hemptinne.** (Comptes Rendus, 133. pp. 934–935, Dec. 2, 1901.)—The author has already shown that a gas which becomes luminous at a certain pressure, under the influence of electric vibrations, becomes luminous at a higher pressure, when it is submitted at the same time to the action of Röntgen rays. He now finds that if radio-active substances are brought near a tube containing air at feeble pressure, and exposed to electric vibrations, the air becomes luminous at the pressure of 44 mm., whilst without the substance the pressure must be diminished to 33 mm. in order to observe the luminescence. The luminosity, which was reddish-violet in the last case, was yellowish-green under the influence of the radio-active substances. Above a large metal plate, which was the seat of Tesla vibrations, a large tube, 1 m. long and 3 cm. in diameter, was suspended horizontally by silk threads; the tube contained air at a pressure of about 10 m. When the tube was brought sufficiently near the plate it became luminous; when moved to a distance the light became feeble, and was finally extinguished. If a radio-active substance were then brought near the tube, yellowish glimmers were given out in the neighbourhood, their extent depending on the distance between the large tube and the plate; when the radio-active substance was displaced along the tube, the glimmering light displaced itself with it. J. J. S.

459. *Chemical Action of Radium.* **Berthelot.** (Comptes Rendus, 133. pp. 973–976, Dec. 9, 1901.)—Experiments were made to determine whether radium exerted any decomposing action on iodine pentoxide, this reaction being chosen on account of its endothermic character. The radio-active material had a mass of 0·145 gr., about one-eighth of this being chloride of radium, and the remainder chloride of barium. It was placed in a very small sealed glass tube which was surrounded by a thin, somewhat wider, tube, around which was placed 4 to 5 grammes of white iodine pentoxide, any volatile products of decomposition being carried off by a current of dry air. The decomposition of the iodine pentoxide was noticed only under the influence of radium, and when the tube containing it was not surrounded by black paper, that is, under the conditions in which the phosphorescence of the mixture manifests itself. The radiations which produce this phosphorescence in consequence of a double transformation of energy played a characteristic part in the actual experiment. Series of experiments were carried out at 10° and at 100°. According to Curie and Becquerel, the energy radiated by a layer of radio-active matter of 2 mm. thickness spread over 1 sq. cm. of surface is about 5 c.g.s. units of energy per second. Calculating from these numbers the amount of iodine set free by the endothermic decomposition of I_2O_5 in the experiment described would amount to not more than $\frac{1}{2\,0\,0\,0}$ of a milligramme. This value corresponds to the order of magnitude of the phenomena observed by the author. J. J. S.

460. *The Radio-activity of Uranium.* **H. Becquerel.** (Comptes Rendus, 133. pp. 977–980, Dec. 9, 1901.)—When in solutions of chloride of uranium containing a little barium chloride, the barium is precipitated in the form of sulphate, the precipitate carries down with itself an active product. The precipitate is not only strongly radio-active, but, according to the proportions of uranium and barium, it may become notably more active than uranium. At the same time the salt of uranium taken from the liquid has become less active. After eighteen successive operations of this sort the author formerly obtained a uranium salt of little activity. The progressive enfeeblement of the products thus got was shown in various ways, *e.g.*, by the action on an electrometer and on a photographic plate. The question arose whether uranium salts which had partially lost their radio-activity regained it after lapse of time; and on examining after eighteen months the progressively enfeebled products which had been prepared it was found that they were almost identical, and that they had spontaneously regained the activity which they had lost. On the other hand, the precipitated barium sulphate was found to have become completely inactive. The loss of activity shows that the barium does not take away the essentially active and permanent part of uranium. There appears to exist an activity peculiar to uranium, although it is not shown that this metal is not intimately joined to another very active product, not separated by the operations described.

The author suggests a hypothesis which is not in disagreement with most of the facts observed. If the emission of the deviable rays, identical with the kathode rays, is the cause of the emission of the non-deviable radiation, which would then be analogous to the Röntgen rays, this spontaneous emission being comparable with the evaporation from an odoriferous body, radio-activity would resemble a known phenomenon. The energy dissipated would be furnished by the active body itself, but the corresponding loss of weight would be too feeble to be observed. In accordance with a hypothesis of J. J. Thomson there would be two kinds of particles of different sizes, the one kind about a thousand times smaller than the other; on separating, the smaller would carry negative charges, and would attain enormous velocities, which would permit their passage through bodies; the others, larger, whose masses would be of the order of those of the electrolytic ions, would possess much smaller velocities; they would, therefore, not pass through bodies, and would behave somewhat like a gas, forming on all bodies, excepting those electrified positively, a material deposit, which would explain the phenomena of induced radio-activity, and the identity of the induction on different solids, whatever their nature. This deposit of matter would be capable of dividing itself in its turn into smaller particles which could pass through glass, giving the rays, deviable and non-deviable, observed with induced substances, and it would be in consequence of this molecular subdivision that induced radio-activity would dissipate itself, even across an envelope of glass. This phenomenon of the setting at liberty of the ions from a part of the molecules in solutions might account for the increase of the inducing power of certain active bodies when they are dissolved. The emanation which produces radio-activity must not, however, be considered as similar to an ordinary gas, for, according to the experiments of Curie, the equilibrium which is established in an enclosure between the active matter and the induced walls is a function of the quantity of active matter, and there is no phenomenon analogous to the maximum tension of a vapour.

In conclusion, the author confirms his previous observation that the radiation from uranium is not modified at the low temperature of liquid air. [See also Abstract No. 2166 (1900).] J. J. S

461. *Chemical Action of Kathode Rays.* **G. C. Schmidt.** (Phys. Zeitschr. 2, pp. 114–115, Dec. 15, 1901.)—In explanation of the decomposition of compounds sensitive to light by kathode rays, Goldstein (Wied. Ann., 1880, p. 832) put forward the hypothesis that a thin layer of ultra-violet light appears at the point where the body is struck by the kathode rays. In the light of our present conception of the kathode rays as consisting of rapidly moving, negatively charged particles, the so-called electrons, this action may, however, be regarded in another way. When, for example, the rays impinge on a salt, like silver chloride, consisting of a positively charged silver atom and a negatively charged chlorine atom, the electron can only be permanently retained by the salt if it satisfies one of the valencies of the silver; the latter will, therefore, not be capable of combining with so much chlorine as before, so that one chlorine atom will be evolved in combination either with a positively charged electron, or with another chlorine atom forming an indifferent chlorine molecule, whilst silver subchloride remains. According to this view all compounds containing volatile acid radicles will be reduced by kathode rays. The number of compounds which can be submitted to this test is, however, small, since owing to the fact that only the exterior layers undergo decomposition by the kathode rays, it is necessary that the chemical reactions employed should be extremely sharp. Such decomposition has been detected in the cases of ferric, mercuric and silver chlorides, which are reduced to lower chlorides; for the last-named compound the composition of the product of the action of the kathode rays was determined by measuring its potential relative to N/10 hydrochloric acid, the value found differing by less than 0·001 volt from that of Ag_2Cl. In addition to the evidence already brought forward by Wiedemann and the author [see Abstract No. 401 (1898)] in support of the view that the coloration produced in alkali kaloid salts is due to the formation of subchlorides or bromides, it is now found that, when potassium chloride is so acted upon, it yields an alkaline aqueous solution.
T. H. P.

REFERENCES.

462. *Action of Light on Metallic Surfaces.* **H. Buisson.** (Annal. Chim. Phys. 24. pp. 320–398, Nov., 1901.)—A paper on the same lines as, but more complete than, the one referred to in Abstract No. 24 (1902). A. D.

463. *Colour Photography.* **W. de W. Abney.** (Soc. Chem. Ind., Journ. 20. pp. 1060–1071, Nov., 1901.)—The paper treats very fully of the colour sensation and luminosity curves of the spectrum, and explains their application to three-colour photography by Ives', Joly's, and Sanger-Shepherd's methods. Some mention also is made of colour printing in opaque inks. [See also Abstract No. 812 (1900).]
G. H. B.

464. *Flying Shadows.* **E. Goldstein.** (Deutsch. Phys. Gesell., Verh. 3. 14. pp. 189–190, 1901.)—This paper contains a description of flying shadows, analogous to those traversing the landscape upon a total eclipse of the sun, seen under a search-light. A. D.

465. *Magnetic Rotation of the Plane of Polarisation in an Absorption Band.* **W. Voigt.** (Ann. d. Physik. 6. 4. pp. 784–793, Dec., 1901.)—A mathematical discussion of the theory of this magneto-optical phenomenon with special reference to the experiments of **O. M. Corbino.** E. H. B.

HEAT.

466. *Petroleum-Ether Thermometers.* **L. Baudin.** (Comptes Rendus, 133. p. 1207, Dec. 23, 1901.)—The author uses, for low temperature work, a petroleum-ether of specific gravity 0·647 at 15° C., which is of lower density than that used by Kohlrausch. This works well, as the ether remains liquid, and quite transparent, at the boiling-point of liquid oxygen.

W. C. B.

467. *Photometric Pyrometer.* **H. Wanner.** (Phys. Zeitschr. 3. pp. 112–114, Dec. 15, 1901.)—The author has designed an apparatus, suitable for practical work, for the measurement of temperature by photometry of monochromatic light issuing from the body whose temperature is to be measured. The principal use of a pyrometer is in measuring the temperature of ovens, and these, in common with all hollow bodies, give practically "black" radiation. Wien's formula is, therefore, generally applicable. The apparatus consists of a direct-vision spectral-photometer, with twin prisms giving monochromatic light of wave-length 0·6563 μ. The comparison light is a 6-volt incandescent lamp, which is standardised against an amyl-acetate lamp. The two illuminations are brought to equal intensity by rotating the eyepiece nicol, which is provided with a scale of degrees. The range of the instrument is from 900° C. to 2,000° C., and this can be further increased by interposing a light-absorbing medium in the path of the radiation from the hot body. To test the accuracy, the author used the instrument to increase the temperature of a "black body" containing a standardised thermo-element. In the measurements, taken on different days, the maximum error was $\frac{3}{4}$ of 1 per cent.

G. H. B.

468. *Production of Low Temperatures.* **d'Arsonval.** (Comptes Rendus, 133. pp. 980–983, Dec. 9, 1901.)—The author gives some notes on the practical details of the methods for producing and maintaining low temperatures. To obtain a temperature of —60°, methyl chloride may be employed which should be put in a porous vessel. Thus the spontaneous evaporation avoids the necessity of blowing into the liquid. To descend to —112° or —115°, carbonic acid or acetylene may be used. The best solvent for these in the state of snow is acetone. For temperatures below —115°, liquid air must be used, to obtain which conveniently the author recommends the Linde apparatus. In conclusion he gives details of the manipulation employed for maintaining constant the low temperatures produced by liquid air.

J. J. S.

469. *Coefficient of Expansion of Concrete.* **W. D. Pence.** (West. Soc. Engin., Journ. 6. pp. 549–559; Discussion, pp. 559–575, Dec., 1901.)—The author describes an elaborate series of tests carried out in the School of Civil Engineering of Purdue University. Concrete bars were made according to a standard specification described by E. Thacher. The length of the bars in the final tests was 36 inches by 4 inches diameter, the section being cylindrical. They were heated in a steam jacket, and the measurements were made by means of an optical lever. The mean results give the value 0·000005 per degree Fahrenheit.

W. W. H. G.

470. *Specific Heat of Tungsten and of Molybdenum.* **E. Defacqz** and **M. Guichard.** (Annal. Chim. Phys. 24. pp. 139–144, 1901.)—The authors employed a Berthelot calorimeter. Two specimens of tungsten were employed, containing respectively 99·81 and 99·87 per cent. of the metal. For tungsten they find the mean specific heat to be as follows: Between 15° C. and 93° C., 0·0340; between 15° and 258°, 0·0366; between 15° and 423°, 0·0375. From those values they deduce the specific heat at $t°$ C., obtaining the value $C_t = 10^{-10}(313{\cdot}903{,}582{\cdot}57 + 516{,}282{\cdot}0216t - 933{\cdot}0108t^2)$. This result is somewhat higher than that of Regnault, who did not give the composition of the metal which he used. The specimen of molybdenum used contained 99·78 per cent. of the metal. For this metal the mean specific heat was determined for various ranges of temperature, the lowest being from 15° C. to 85° C., the greatest from 15° to 444°. The constant value 0·073 was found for the specific heat, which is again slightly above that obtained by Regnault. W. S.

471. *The Theoretical Evaluation of* γ. **J. H. Jeans.** (Phil. Mag. 2. pp. 638–651, Dec., 1901.)—A gas consists of molecules each having n degrees of freedom, including three of translation. If E be the mean value of the energy of translation [which the author does not define], E + F the whole mean kinetic energy, and if, in stationary motion, $F = f(E)$, then—

$$\gamma = 1 + \frac{2}{3\left\{1 + f'(E)\right\}}, \text{ where } f'(E) = \frac{d}{dE} f(E).$$

If Boltzmann's assumptions are now made—

$$f(E) = \frac{n-3}{3} E, \text{ whence } \gamma = 1 + \frac{2}{n}.$$

This result, being impossible for polyatomic molecules, must be got rid of if not *à priori* by rejecting the assumption, then *à posteriori* by introducing a new agent; this new agent is ether, as in former papers by the same writer. And it gives great freedom of hypothesis. Ether is here introduced as a vehicle for correspondence by which energy is interchanged between molecules, not as itself possessing energy. To begin with, there is assumed to be no dissipation, all the energy entrusted to ether by a molecule being absorbed by other molecules. In the stationary state E_0, F_0, are the values of E, F and $F_0 = f(E_0)$. Then, generally, $\frac{dF}{dt} = \chi(E_0)\left\{F - f(E)\right\}$, where χ denotes some function. It is then assumed that E and F will oscillate about, and not depart widely from, their mean values, conditions which are expressed by the equations

$$E = E_0 + E_1 \epsilon^{ipt}, \quad F = F_0 + F_1 \epsilon^{ipt},$$

and if ρ denote density [which is not defined], and π denote pressure, connected with E and ρ by the formula $\pi = \lambda E \rho$ (λ being constant) then also—

$$\pi = \pi_0 + \pi_1 \epsilon^{ipt}, \text{ and } \rho_0 = \rho_1 + \rho \epsilon^{ipt}.$$

From these data the author deduces—

$$\gamma = 1 + \tfrac{2}{3}/\left\{1 + f'(E)\right\}\left(1 + \frac{ip}{\chi(E)}\right),$$

which is thus a generalised form of γ, which, when p is infinite, reduces to $1\frac{2}{3}$. The best method of determining γ is by its relation to the velocity of

sound. Generally, if a be the Newtonian velocity, the actual velocity is $a\sqrt{\gamma}$. The author explains the relation between the value of γ, as determined by the velocity of sound, and its true value. So long as $p/\chi(E)$ is inappreciable the difference is small, but increases as p increases.

As an illustration of the theory, the lag in rotatory motion of air is considered, the molecules being rigid bodies having two degrees of freedom of rotation. The author then again introduces the conception, which we owe to him, of subsidiary degrees of freedom. They are those for which the transfer of energy depends as much on ether interactions as on encounters. If a molecule has $n+3$ principal, and m subsidiary degrees, he finds that—

$$\frac{\Gamma-1}{2} = \{n+3+3mf'(E)\}\left(1+\frac{ip}{\chi(E)}\right)$$

At low temperatures γ approximates to the classic form $1+\frac{2}{n+3}$, but increases with increasing temperature.

The conclusions are :—

(1) If there be no energy but that of translation $\gamma = 1\frac{2}{3}$. (2) If γ differs from $1\frac{2}{3}$, it is generally a function of the temperature. (3) Its general value is $1+\frac{2}{n+3+3\Sigma f'(E)}$, the summation Σ including all subsidiary degrees of freedom. Also $f(E)$ is very small at normal temperatures. As the temperature rises, more pairs of molecules approach each other sufficiently near to affect sensibly their internal vibrations. S. H. B.

472. *Heat Radiated from a Wire in Vacuo.* **R. Kempf-Hartmann.** (Phys. Zeitschr. 3. pp. 109–110, Dec. 15, 1901.)—A platinum wire was stretched in a long glass tube, and from its centre was hung a small weight, serving as an index of the extension of the wire ; a side tube contained this weight and a small scale. The author measured the current, the sinking of the weight, and the times required to reach a constant deflection and to return to zero, at different degrees of vacuum. The sensitiveness of the arrangement increased very largely with the degree of vacuum. The value of the square of the current divided by the deflection was, at a kathode-ray vacuum, 0·000085, and at 6 or more cm. of mercury, 0·011. The time required to reach a constant deflection increased with the degree of vacuum.

G. H. B.

REFERENCES.

473. *Correction for Expansion of Thermometer Scales.* **H. F. Wiebe.** (Archives Néerlandaises, 6. pp. 323–332, 1901.)—In general, thermometers are made of the same kind of glass throughout, bulb, tube, and scale ; but in certain standard thermometers the scale is of material different to the bulb and tube. The author investigates the correction to be applied in the use of these instruments. R. A.

474. *Isothermals of Hydrogen.* **E. H. Amagat.** (Phil. Mag. 2. pp. 651–653, Dec., 1901.)—This is a correction of a statement by Rose-Innes that the isothermals of hydrogen as experimentally determined by Amagat are a set of parallel straight lines. [See Abstract No. 2126 (1901).] R. E. B.

475. *Meniscus Changes of Saturated Vapours.* **V. Blaess.** (Phys. Zeitschr. 3. pp. 115–117, Dec. 15, 1901.)—The author gives a graphic method by which the change in volume of a liquid corresponding with any given change in its state can be determined. T. H. P.

SOUND.

476. *Interference Phenomena.* **D. van Gulik.** (Archives Néerlandaises, 6. pp. 287–293, 1901.)—The author observes that in the noise emitted by the steam escaping from the safety valve of a locomotive on the point of starting, definite and different pitches may be noticed, provided the observer takes up certain positions on the platform of the station. The phenomenon is traced to the reflecting action of the platform, and this is verified by experimenting with a large flat wooden board which was moved about to various positions. The tone rose in pitch when the board was moved vertically upwards towards the observing ear. By calculation, it is found at what positions certain pitches should be expected, and those results are in fair agreement with experiment. The same effects are observed and verified near a small waterfall. The phenomenon is compared to the action of the Fresnel mirrors and the Lloyd's mirrors in light. The source of sound emits a mixture of harmonic vibrations of different periods, so that after reflection a kind of sound spectrum is formed by the interference of the different constituents. At different points near the reflecting surface, the different harmonic constituents stand out. J. W. P.

477. *Study of Speech by Microphonic Currents.* **A. Blondel.** (Comptes Rendus, 133. pp. 786–789, Nov. 11, 1901.)—The author describes a new method for following the transformations of sound vibrations into electric oscillations by making use of a microphone, and of a reinforcing circuit. The resonance apparatus comprised three circuits, with elevating and lowering transformers as well as a condenser regulated to give the maxima of sound and accuracy. A bifilar oscillograph was employed and was branched between the secondary terminals of the second transformer. Curves are given corresponding with the vowels *a, e, i, o,* sung as nearly as possible on the note la_3, and these show very distinctly the periodicity of the phenomenon and the differences between the several vowels. T. H. P.

REFERENCE.

478. *A Century of Progress in Acoustics.* **J. Loudon.** (Science, 14. pp. 987–995, Dec. 27, 1901. Presidential address to the American Association for the Advancement of Science.)

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

479. *Unipolar Rotation.* **G. R. Olshausen.** (Ann. d. Physik, 6. 4. pp. 681–725, Dec. 5, 1901. Abstract from the Berlin Inaugural Dissertation.)—The Biot-Savart law of action between electric currents and magnets leads, according to some writers, more particularly E. Lecher [see Abstract No. 94 (1900)], to inconsistent results. And certain experiments have been made with specially designed apparatus by Lecher, König, and Pohl with a view to prove the incorrectness of the law.

The present writer maintains that if all the electric field is duly brought into account, results are obtained in accordance with theory, and there is no inconsistency. He first enunciates the law in the following form: "The action of an elementary electric current on a magnetic pole is inversely proportional to the square of the distance r between the two, and directly proportional to the sine of the angle which r makes with the direction of the current. He assumes also that if the current element acts on the pole with a definite force applied at the pole, the pole acts on the current element with an equal parallel and oppositely directed force applied at the element."

Then, after explaining the theory of the Biot-Savart law, he describes and discusses the three experiments of Lecher, König, and Pohl.

The results of the author's investigation are summarised in five conclusions, of which the following are of general application: (1) That in the form above given the law leads to results consistent both with these experiments and with theory; (2) any definite portion of an electric current contributes, or does not contribute, to the total result, viz., moment of rotation of the pole about an axis, according to the point of view taken; we may say, namely, that the current acts as a whole; (3) the law has no meaning except as applied to the entire current, supposed closed; (4) it is impossible by any measurements to determine to which part of a closed circuit the action on the magnet is due. S. H. B.

480. *Electromotive Force Produced by Unipolar Induction.* **O. Grotrian.** (Ann. d. Physik, 6. 4. pp. 794–817, Dec., 1901.)—A cylindrical magnet is rotated, between coned screw-ends, about its axis. The motor used drives it at speeds up to 30 revolutions per second. Brushes touch its surface at the centre of the magnet, and also on the framework beyond its two ends. On connecting the brushes to a quadrant electrometer, a potential difference as much as 2 millivolts was found. Magnetic lines of force are cut in the rotation, and theory shows that the c.m.f. should be $E = 4\pi\mu v$, where μ is the pole-strength, and v the frequency of rotation per second. By measuring the magnetic moment of the magnet, and hence μ, the author gets a theoretical value of E. His results are: (1) In open circuit of an ordinary unipolar machine there exists free electricity due to induction. (2) The potential difference of this free electricity is equal to the total e.m.f. running in the closed circuit. (3) Reckoning from the free magnetism, a value was found for the e.m.f. about 15 per cent. less than the value found in practice. The question as to the cause of this discrepancy remains at present open. P. E. S.

481. *Production of a Magnetic Field by Electric Convection.* **A. Righi.** (N. Cimento, 5. pp. 233–256, Oct. 1901.)—The following four analogous phenomena, following on electromagnetic theory, have not yet been definitely verified by experiment: (1) An electric charge in motion should produce a magnetic field. (2) A varying magnetic field should produce an electric field. (3) A magnetic pole in motion should produce an electric field. (4) A varying electric field should produce a magnetic field. Attempts have been made to verify the first two phenomena, but the last two have not yet been experimentally tested.

The author then reviews critically the various experiments made. Rowland first experimented on the first phenomenon, observing the effect of a charged rotating disc on a magnetic needle. He obtained results corresponding to the effect indicated by theory. Lecher, in 1884, repeated the experiments with a similar apparatus, but obtained no deflection of the needle. Röntgen later replaced the charged disc by a disc of insulating material, charged inductively by two fixed metal discs, one on each side of it. Deflections were produced which, however, he afterwards found to be due to other causes than a charge on the rotating disc. Himstedt repeated Rowland's experiment, using two rotating glass discs, rendered conducting by graphite, with the lower needle of an astatic pair between the discs; the use of graphite reduced the Foucault currents, due to the earth's magnetism, to a minimum. The deflections obtained were large and corresponded with those calculated, but were not proportional to the potentials of the discs. In 1889 Rowland and Hutchinson repeated Himstedt's experiments, and obtained deflections corresponding to the calculated, but which were not equal when the sense of rotation of the discs was changed. In 1900 Crémieu made the experiment with an apparatus of modified form, and obtained a negative result [see Abstract No. 1666 (1900)]. Later he repeated the experiment with an apparatus more similar to Rowland's, also with negative results [see Abstract No. 144 (1901)]; in this, between the moving charge and the needle, were a mica disc with tin-foil sectors and a brass disc; on removing the brass disc, when the arrangement corresponded exactly with Rowland's, he obtained deflections similar both in magnitude and sense to Rowland's. These, however, he attributes to electrostatic action and not to magnetic effects. Crémieu again had negative results from a different form of apparatus [see Abstract No. 1916 (1901)]. In 1901 Pender repeated Rowland's experiments under his direction, substituting a coil connected to a galvanometer for the magnetic needle, and obtained results agreeing very closely with theory [see Abstract No. 2140 (1901)]. Adams confirmed these results by an apparatus of somewhat different design (see Abstract No. 2136 (1901)]. The author criticises the various experiments at length, and points out that Crémieu makes the assumption that a metal sheet between the moving charge and the needle cannot affect the magnetic action of the former on the latter. The author, however, thinks it possible that charges may be induced in this sheet which neutralise the action, the sheet, from its position and shape, acting differently from the metal cage surrounding the needle in Rowland's experiments. On the other hand he points out that Rowland's experiments are not free from objections, as the results showed that all the sources of error had not been found or completely eliminated. Nevertheless he considers the evidence to be in favour of the truth of the first phenomenon.

The second phenomenon was tested experimentally by Lodge in 1889, by observing the motion of a gold leaf in a varying magnetic field. He obtained results concordant with theory, but did not consider the experiment decisive

Crémieu in 1900 obtained a negative result with a different apparatus [see Abstract No. 106 (1901)], but Wilson showed that in this apparatus deflections opposite to those sought for must tend to be produced by other causes, and that consequently the fact that they were not produced proves the existence of forces due to the second phenomenon [see Abstract No. 2138 (1901)]. The author then describes an arrangement designed by himself for testing the second phenomenon. A needle consisting of a tube of cigarette paper is charged by a dry pile, and suspended in the hollow core of a powerful electromagnet, so as to hang in the gap. He shows that owing to want of perfect symmetry in the needle, the suspension and the field, deflections may be produced by various causes, and he describes the various precautions taken to eliminate these deflections. He obtained the results expected, but the tests were not sufficiently free from error to be considered decisive.

Reviewing the experimental difficulties attendant on the verification of the four phenomenon, he considers that the second and third offer fewer difficulties than the first and fourth, and points out that the verification of any one entails the truth of all four. G. H. B.

482. *Electric Convection.* **V. Crémieu.** (Soc. Franç. Phys., Séances, 2. pp. 152–170, 1901.)—This paper contains a *résumé* of former experiments and an account of further ones, confirming the conclusion that electric convection does not produce any magnetic effect. Also, convection may maintain a constant difference of potential between two points connected by a metallic conductor along which conductor there is a magnetic field, the lines of force in which are not closed; there may thus be open currents. [Compare Abstracts Nos. 1666 (1900), 144 and 1100 (1901), 56 and 316 (1902).] A. D.

483. *Electromagnetic Units.* **G. Giorgi.** (Elettricità, Milan, 20. pp. 787–788, Dec. 14, 1901. Abstract of a paper read before the Italian Electrotechnical Association, Oct. 13, 1901.)—Heaviside's suggestion as to the "rationalisation" of the electromagnetic units and the elimination of the 4π from the formulæ is explained. The author starts from the equation Work $= ei$ and Work $= fg$, where f is the magnetomotive force and g the magnetic current (rationalised formula), and the circuital equations $e = \pm g$ and $f = \pm i$; he then, retaining the watt, the volt, and the ampere, shows that the corresponding terms are the following, the magnetomotive force being measured with reference to ampere-turns and thus eliminating the π.

Electromotive Force = volt = magnetic current.
Electric Current = ampere = magnetomotive force.
Quantity of Magnetism = weber = electromotive impulse.
Quantity of Electricity = coulomb = magnetomotive impulse.
Electric Resistance = ohm = magnetic conductance.
Magnetic Resistance = mho = electric conductance.
Electrostatic inductance = farad = magnetic self-induction.
Magnetic Inductance = henry = electric self-induction.
Electrostatic Reluctance = farad^{-1} = (magnetic mobility).
Magnetic Reluctance = henry^{-1} = (electric mobility).

All this works out if an m.-k.-s. (metre, kilogramme, second) system be adopted; and there is no need for c.g.s units. Such an m.k.s. system would be not only absolute, but rationalised, and the same for electrostatic and electromagnetic units. On this system K represents farads per metre, and

instead of μ we would have, say, λ, the magnetic inductivity in absolute units, while μ stands for λ/λ_0, the ratio between the inductivity of the medium and that of the ether. For the ether, $K_0 = 0{\cdot}000000{,}000008{,}842$ and $\lambda_0 = 0{\cdot}000001{,}256637$. A. D.

484. *Electrostatic Equilibrium of two Parallel, Uniformly Charged Cylinders of Revolution.* **J. B. Pomey.** (Écl. Électr. 29. pp. 457–463, Dec. 28, 1901.)—Two parallel telegraph wires, each of which is of a length much greater than the radius of its cross section, are mathematically to be considered as two parallel straight cylinders. Each being uniformly charged with electricity, the problem is to find the potential at any point, and hence the capacity of either wire. It is a problem in two dimensions, a plane being taken at right-angles to the wires, which are represented by two circles on the plane. If we can find a function p which has a constant value round the contour of either circle satisfies the condition $\Delta p = 0$ at all points in the plane exterior to either circle, and is equal to $\log r$ at an infinite distance, r being measured from either circle, that function must be the required potential.

Two conjugate points are taken, a in the larger, a' in the smaller circle, and r, r', are the distances of any point from a, a', respectively. At any point on the contour of the larger circle $r/r' = \mu$ ($\mu < 1$) and the radius is $aa'\mu/(1-\mu^2)$. At any point on the contour of the smaller circle $r/r' = \lambda$ ($\lambda > 1$) and the radius is $aa'\lambda/(\lambda^2 - 1)$.

The author begins with the function—

$$F = \log\{\tan(A + iB) - \tan C\}, \text{ A, B, C being real.}$$

P and Q, the real and imaginary parts respectively of this expression, are first determined in terms of A, B, and C.

He then assumes that—

$$A = \frac{\pi}{2}\log\left(\frac{1}{\lambda\mu}\,\frac{r}{r'}\right)\Big/\log\frac{\lambda}{\mu} \text{ and } B_\kappa = \frac{\pi}{2}\frac{1}{\log\frac{\lambda}{\mu}}(\phi - \phi' + 2\kappa\pi),$$

ϕ, ϕ', being the angles made with aa' by r, r' respectively, κ a quantity which assumes all integral values, and B_κ the value of B for a particular value of κ.

He also writes—

$$C = -\frac{\pi}{2}\frac{\log\lambda + \log\mu}{\log\lambda - \log\mu}.$$

The required potential function for the case in which the sum of the charges is -1, is found to be—

$$p = \sum_{-\infty}^{+\infty}\left(P_\kappa - \frac{1}{2}\log\frac{1}{\cos 2C}\right) + \text{a constant.}$$

It is shown (1) that the series converges; (2) it satisfies $\Delta p = 0$; (3) $p = 0$ on the contour of either circle; (4) $p = \log\frac{1}{r}$ at an infinite distance. It is shown also that infinite values of the logarithm cannot occur at any point exterior to the two circles. The distribution of the charge -1 between the two wires is then determined, and thence the writer proceeds to the general case in which the charges on the wires are q, q'. S. H. B.

485. *Electric Ions in the Higher Layers of the Air.* **H. Ebert.** (Terrestrial Magnetism, 6. pp. 97–118, Oct., 1901.)—Following the methods of Elster and Geitel [see Abstracts Nos. 2023 (1900) and 1918 (1901)], but using free balloons

the following results are found : (1) Observations of atmospheric electricity can be taken accurately and easily with the other usual observatory work by the balloon method. (2) At increased heights there is an undoubted increase in the speed of discharge, independent of the discharges on the earth, which latter are a disturbing factor in mountain observations. (3) Up to 3,000 metres it was found that negative discharge occurs faster than positive. At greater heights the rates of discharge become more and more nearly equal as we ascend. (4) The increase in the rate of discharge with increase in height is not such as to enable the relation to be expressed in a simple formula with few constants ; hence it is to be supposed that the physical conditions, specially as to moisture, in each layer through which the balloon passes, have preponderating influence. (5) In dry, clear air the rate of discharge is nearly as great as near the earth ; but in damp air, specially when the dew-point is reached or light clouds exist at the point in question, the discharge is much reduced. (6) Great rate of discharge occurs when, the air having been clear and air currents small for many days, ions exist in large quantity. [See also Abstract No. 1917 (1901).] P. E. S.

486. *Observation of Distant Storms and Study of Atmospheric Electricity.* **T. Tommasina.** (Comptes Rendus, 133. pp. 1001–1003, Dec. 9, 1901.)—By means of the electroradiophone already described [see Abstract No. 489 (1901)], the author has heard storms, in one case 200 km., in another case 400 km. away. A curious point is that in some thunderstorms the radiophone is not affected, from which the author concludes that the lightning discharge in those cases is non-oscillating. The main purpose of the paper is to describe the variations in atmospheric electricity perceived by means of the electroradiophone when the author was on the look out for distant storms.

He heard slight sounds at regular intervals ; these were not connected at all with storms or rain, but were purely due to ordinary atmospheric electricity entering the antenna of the instrument. As the result of a set of observations from the middle of October, 1901, for the next three weeks it was found that a maximum of electricity in the morning had a progressive diminution until it finally disappeared, and only one oscillation in the curve occurred, having its maximum in the early hours of the night. P. E. S.

DISCHARGE AND OSCILLATIONS.

487. *Conditions Controlling Potential Fall at Electrodes in Vacuum-tube Discharge.* **C. A. Skinner.** (Phil. Mag. 2. pp. 616–638, Dec., 1901. Paper read before the American Association for the Advancement of Science, Aug., 1901.)—An experimental investigation showing that the high potential required to produce a discharge between electrodes in a vacuum-tube, when these are placed close together, is due to a drop of potential between metal and gas, and examining the conditions controlling this drop of potential. The gas used was purified atmospheric nitrogen. The variation of the drop of potential at the electrodes, with their distance apart, is shown by a table and by curves As the anode is moved towards the kathode, the drop at the anode remains constant along the positive column ; within the Faraday dark space it first increases to a certain maximum value, then falls rapidly to a value approximately zero in the negative glow ; retains this zero value throughout the negative glow, but increases very rapidly on entering the kathode dark space. Comparing the curves with those of H. A. Wilson for

cross-conductivity [see Abstract No. 1669 (1900)], the author concludes that the conditions which increase the cross-conductivity decrease the drop of potential at the anode; and, therefore, if the former depends simply on the degree of ionisation, the anode drop is decreased by increased ionisation. The author, however, introduces the factor of the velocity of the discharging ions, and explains the variation in the drop in the different parts of the tube by saying that, other conditions being the same, the greater the velocity of the discharging ions, the greater the drop at the anode. The same argument applies to the fall of potential at the kathode, for which tables are also given. Some of the results in these tables show that, when the electrodes are close together, the gradient in the gas is inappreciable, and that the high discharge-potential is wholly made up of the drops at the electrodes. The variation of the potential fall at the electrodes with current-density and with gas-pressure is then investigated. With moderate current-densities the anode drop is constant, other conditions being constant, but it increases with gas pressure, that is, it increases with the force with which the negative ion is driven against the anode. The kathode fall increases with increasing currents, decreases with increase of pressure. The author deduces a formula giving the kathode-fall within a given range of pressures for the particular metal and disposition of electrode and the gas used. From investigation of the effect of the area of the kathode on the drop at that electrode, the conclusion is drawn that the kathode-drop may be designated as a linear function of the current-density. Having given curves showing the effect of the kind of metal on the kathode-fall, the author makes the *general* conclusion that for a plane kathode the relation between kathode-fall V, current-density i, and gas-pressure p, may be expressed by the equation—

$$V = C + \frac{c}{p}(i - a),$$

where a is a constant; c, a constant depending on gas used; C, limiting value of kathode-drop for infinite pressure, depending both on metal and gas used. Finally, the author compares the results at the kathode with those at the anode. W. C. H.

488. *Electrification of the Air by Glow Discharge.* **O. Lehmann.** (Ann. d. Physik, 6. 4. pp. 661–680, Dec., 1901.)—The following are the principal conclusions at which the author arrives as the result of his experiments :—

(1) Convective transfer of electricity by glow discharge at a point cannot be considered as due to capacity of the air to act as a conductor. (2) An electrically charged conductor (or insulator) brought into a unipolar electrical wind does not lose its charge if the electrifications are similar, even if its potential is much higher than that of the electrified air. In the opposite case it loses its charge completely, and acquires the opposite one, corresponding to the prevailing potential at the particular place. (3) Ordinary metallic sounds do not give the true course of the equipotential surfaces and flow lines, especially with low potential values; these are given well, however, by drop or flame collectors, in so far as they do not themselves give rise to change in the electrical condition. (4) Positive and negative electrified air diffuse in the same way. The electrification can therefore not be conditioned by the presence of free moving electrified particles of different nature (electrons). (5) The convective flow fills the whole space around the point. When lycopodium powder is sprinkled in the neighbourhood, the region

mapped out by the Kundt's figures thus obtained is not the discharge region but it is the region in which the electric wind gives rise to sufficiently high potential differences to produce the glow discharge on striking against the plate. (6) Behind an insulating plate, set up perpendicularly to the lines of flow, there exists a space free from electrified air (electric shadow). (7) When an electric wind proceeds from two points placed opposite to each other, a rotatory movement is produced in the air, and a varying arrangement of the stream lines of the electrical particles takes place. (8) In the region in which both positively and negatively electrified air is present, the air is apparently conducting. (9) The relation between the velocities of discharge of conductors charged oppositely, but to an equal extent, allows of drawing a conclusion as to the mass relation of positive and negative electric particles at the place in question. (10) The electric winds proceeding from the two points combine, with equal value of the pressure at both electrodes, only partially, a greater part escaping unchanged to the walls of the room. The electric particles do not follow the lines of force which exist before the beginning of the discharge, but the lines of force of the field produced by themselves, which from the first is very different. (11) With unequal supply of electricity at the two electrodes, the electrified air appearing in greater quantity envelops also the opposite electrode. (12) Two sounds which are placed only in positive or only in negative electric wind, give on being joined a current only until the sound at the place of lower potential has attained the potential of the other ; on the other hand, two sounds which are put one in positive and the other in negative wind, give a continuous current. (13) Alternating currents produce no electric wind, and do not make the air apparently conducting. J. J. S.

489. *Disruptive Discharge in Electrolytes.* **H. Bagard.** (Comptes Rendus, 133. pp. 927–929, Dec. 2, 1901.)—In order to obtain the discharge in conducting liquids with simple apparatus, it is important first of all to reduce as much as possible the surfaces of the metallic conductors between which it is sought to produce a spark in the liquid. The author employs two metal wires, 1 mm. in diameter, arranged horizontally in a line, and insulated from the liquid by a thick sheath of solid dielectric, such as ebonite, up to the immediate neighbourhood of the free extremities. In the second place, it is necessary to employ one of the known methods of the dynamical discharge. For example, two insulated Leyden jars were taken, and their inner coatings joined respectively to the two poles of an electrical machine, and to the two balls of an ordinary discharging apparatus, operating in air. The outer coatings were joined to the two branches of the discharger in the liquid B. This last, owing to the conduction of the liquid, maintains the equality of the potentials of these two coatings at the time of charge, which is relatively slow. But if the discharger, A, is regulated for a sufficient explosive potential, when a discharge of the inner coatings is produced, the quick discharge which tends to take place between the outer coatings is not able to occur by simple electrolytic conduction, and a spark passes across the dielectric. With large surfaces the discharge would happen exclusively by conduction. The liquid discharger may be placed in an independent circuit. The explosive distance may be raised to 3 mm. and more in solutions of high conductivity, such as copper sulphate and sulphuric acid.

If an induction coil be used instead of isolated sparks in the liquid, a close succession of sparks may be obtained, and their frequency may be regulated at will. J. J. S.

490. *Length of Break-Spark in Inductive Circuit.* **R. Beattie.** (Phil. Mag. [6] 2. pp. 653–658, Dec., 1901.)—This paper gives the results of measurements of the length of the spark which appears on suddenly breaking an inductive, current-carrying, electric circuit, the object being to gain some definite information regarding the influence of the material of the break-poles on the spark-length. One of the poles was held permanently in position, while the other could be rapidly drawn away by a device which secured uniformity in breaking the circuit. The time taken by this moving pole to travel l centimetres was $0{\cdot}027\sqrt{l}$ seconds, and as the longest sparks observed were about 7 cm. in length, their duration was thus 0·07 second. The accompanying table gives the results of the experiments, shown also by curves in the paper.

Current in Amperes.	Spark-length in Centimetres.												
	Iron.	Bismuth.	Copper.	Platinum.		Carbon.	Tin.	Nickel.	Aluminium.		Zinc.	Lead.	
				Fixed pole positive.	Fixed pole negative.				Fixed pole positive.	Fixed pole negative.		Fixed pole positive.	Fixed pole negative.
1·2	...	0·2	0·15	...	...	0·05	0·15	0·05	0·2	0·2	0·15	0·2	0·2
1·8	0·15	0·6	0·30	0·15	0·15	0·15	0·38	0·30	0·4	0·4	0·30	0·5	0·5
2·4	0·38	—	—	—	—	—	—	—	—	—	—	—	—
3·0	0·62	1·4	0·70	0·31	0·31	0·40	0·94	0·90	0·75	0·75	0·75	1·4	1·4
6·0	2·25	2·5	1·9	1·25	1·4	1·7	2·7	2·5	1·9	1·9	2·25	2·8	2·9
9·0	3·75	3·5	2·9	2·25	2·5	3·4	4·0	4·0	3·1	3·1	3·4	3·75	4·4
12·0	5·13	4·0	4·0	3·25	3·7	5·3	5·2	5·4	4·35	4·5	4·4	4·7	5·4
15·0	6·25	4·6	5·0	4·37	5·0	7·2	6·6	6·5	5·6	6·1	5·4	5·5	6·5

The curves show that the spark-length varies with the current in different ways for different materials, so that the material which gives the longest spark with a particular current does not necessarily give the longest spark with another current. But the most interesting point brought out is in connection with the behaviour of the different materials on reversal of the current. With the metals, iron, copper, tin, nickel, zinc, and with carbon, reversal of current produces no perceptible difference in the spark-length; but with lead, platinum, and aluminium poles the spark-length for the larger currents is notably greater when the fixed pole is negative than when it is positive. W. C. H.

491. *Characteristics of the Spark of an Oscillating Discharge.* **C. Tissot.** (Comptes Rendus, 133. pp. 929–931, Dec. 2, 1901.)—Further remarks are made on the method of observing the spark previously described [see Abstract No. 1518 (1901)], in which a rotating mirror and cylindrical lens are used. It has been found, on micrometric examination, that the images of the successive sparks are not rigorously equidistant. The first interval is always distinctly greater than the others. The following intervals successively decrease very slightly. While the differences are small they seem not to be accidental, for the same tendency appears in all the experiments.

The first interval appears to depend upon the explosive distance, and

increases with it. Hemsalech has shown that there exists an important difference between the first spark of an oscillating discharge and the following ones. In the first the spectral lines due to air only appear, whilst the lines of the metal appear in the others. J. J. S.

492. *Resonance of Electric Waves Determined by Coherer.* **F. Kiebitz.** (Ann. d. Physik, 6. 4. pp. 741–753, Dec., 1901.)—Continuing the investigations described in Abstract No. 1929 (1901), the author finds that a coherer allows a determination of resonance to be made provided care is taken that the wave trains sent are always precisely alike. This was done by using with the induction coil a vibrating interrupter of considerable mass. The best results were obtained from iron coherers vigorously shaken. The best arrangement of receiver was found to be that of two insulated wires, each a quarter wave-length long, one on each end of the coherer. The coherer was also found to work on a circular receiver whose length was a whole wave-length. E. H. B.

493. *Hertz Waves in Water.* **C. Gutton.** (Journ. de Physique, 3. pp. 752–756, Dec., 1901.)—The resonator used was a copper ring 36 cm. diameter and 0·3 cm. thick. Waves were passed from a Hertz vibrator along two parallel wires 38 cm. apart, which at 250 cm. from the vibrator passed into a tub to hold the resonator, and afterwards extended a distance of 400 cm. within a long trough, being 4 cm. apart and connected by a bridge. With first air, then water in tub and trough, the wave-lengths were found to be invariable, the resonator either in or perpendicular to the plane of the wires. But when the resonator was kept in air and the wires immersed in water the wave-length was reduced from $\frac{\lambda}{2} = 145$ cm. in air to $\frac{\lambda}{2} = 17{\cdot}5$ cm. in water, these numbers giving 8·3 as the refractive index of water for the waves. These experiments contradict Turpain's statement that the period of a resonator is independent of the medium in which it is immersed. G. E. A.

494. *Oscillations in the Hertz Vibrator.* **K. R. Johnson.** (Journ. de Physique, 3. pp. 756–759, Dec., 1901.)—An error in an equation in a previous paper [see Abstract No. 1927 (1901)] is corrected. The oscillations which take place in each half of the vibrator resemble those in a closed organ-pipe, the ball corresponding to the open end of the pipe and the sparks to the intermittent compressions caused by the movement of the reed. It is not necessary to assume a metallic conductivity in the spark-gap of the Hertz vibrator. G. E. A.

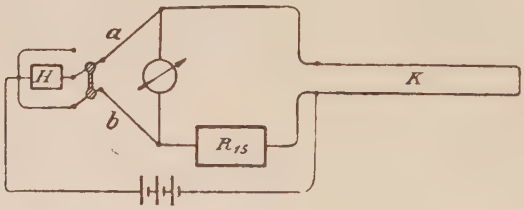
ELECTRICAL PROPERTIES AND INSTRUMENTS.

495. *Contact Electricity.* **O. Knoblauch.** (Zeitschr. Phys. Chem. 39. pp. 225–244, Dec. 5, 1901.)—Platinum and paraffin are charged, upon contact with powders and subsequent separation, in general positively if these powders possess acid properties when dissolved in water, negatively if they are alkaline, positively or negatively in about equal numbers of cases if they are neutral. Sulphur generally becomes negative, and is positively charged only after contact with some acids; glass generally becomes posi-

ve, and is negatively charged only after contact with some bases. Some organic dye-stuffs in powder, not necessarily bases, but also salts, give a strongly negative charge to platinum, paraffin, sulphur, and glass. The author develops the theory that these differences are due to the relative velocities of ions in the surface-films of moisture on the plate and the powder; for example, if powdered tartaric acid be thrown on to platinum there is diffusion between the surface film on the powder and that on the platinum, and the hydrogen ions in the former load the platinum plate more rapidly than the acid-radicle ions do; so that if the powder be thrown off before saturation-equilibrium has been established, the platinum remains positively charged. The potential-difference would therefore depend on the duration of the contact. With salts the difference between the velocity of the ions is much smaller, and trifling causes affect the result, which is variable. With sulphur the surface-film always contains H_2SO_4, which can (Emich) be detected by litmus; and there is a tendency for the H ions to wander into the film on the powder, leaving the sulphur negatively charged; while glass presents a faintly alkaline film on its surface, and the tendency is for this to become positively charged. The facts observed are in agreement with Coehn's observation that substances of greater dielectric constant become positively charged; the ions tend, in addition to the above process of diffusion, to travel in the liquid film towards the substance of greater dielectric constant. The greater their velocity the more rapidly they accumulate towards its surface, with effects analogous to the preceding, but which may or may not concur with those of ordinary diffusion of ions. This latter is the dominant factor in cases of acids or bases, but may have little or no effect where the substances are neutral. The theory of accumulation by diffusion does not apply to prolonged contacts or to contact between a solid and a liquid; in such cases Coehn's principle is more applicable. It does, however, apply to the contact of two metals in a gas, oxidation-products being dissolved in the surface-film of moisture; there are more OH-ions about the surface of a more oxidisable metal, and these, leaving that metal, leave it positively charged. A. D.

496. *Measurement of Mutual Induction by the Electro-dynamometer.* **R. Manzetti.** (Accad. Lincei, Atti, 10. pp. 179–186, Oct. 20, 1901.)—The paper describes the measurement of very small coefficients of mutual induction by means of alternate currents and a differential dynamometer designed by the author. Owing to the difficulties attendant on the use of the ballistic galvanometer, due to variations of zero, of H and of the strength of the controlling magnet, when great sensitiveness is required, the author considers the method described to be superior to the ordinary one. The differential dynamometer has two coils, one on each side of the moving system, with their axes parallel, but one above the other. The moving system consists of two bundles of soft iron wire fixed to an aluminium stem, one bundle before each coil. The two bundles are at right-angles to each other, each making an angle of 45° with the axis of the coil. By adjusting the position of one coil, the instrument can be made to give no deflection when an alternate current is passed through the two coils in series. The coefficient of mutual induction to be measured was compared with that of a standard pair of coils. The primaries were connected in series, and the secondaries, one to each coil of the dynamometer with an adjustable resistance. When balance is obtained the coefficients of mutual induction are to one another as the resistances of the two secondary circuits. G. H. B.

497. *Testing Telegraph Cables.* **K. Strecker.** (Elektrotechn. Zeitschr. 22. pp. 959–960, Nov. 14, 1901. Paper read before the Elektrotechn. Verein, Oct. 22, 1901.)—The author first describes the weekly conductivity and insulation-tests as normally carried out in Germany, in which the variation in resistance of the gutta-percha insulation with temperature is allowed for, using the formula $r_t = r_0 . f^t$, where $f = 0{\cdot}87$ to $0{\cdot}89$, to reduce the resistance to 15° C. In order to simplify the measurements and calculations, and increase the accuracy, the following arrangements are suggested, viz.: In order to obtain the mean temperature of the conductors without calculation, two of the cores are looped, as at K, and the open ends connected to a Wheatstone bridge as shown: *a* and *b* are each 1,000 ohms, and an auxiliary resistance H is employed which, by means of a double-pole switch, can be added either to



a or to *b*. R_{15} is a resistance box adjusted to the normal resistance of the cable at 15° C., which is previously determined. By adjusting H, a balance is obtained when $R_t : R_{15} :: (a + H) : b$, whence—

$$\frac{R_t - R_{15}}{R_{15}} = \frac{(a + H) - b}{b} = \frac{H}{b},$$

and $t = 15 + H/3{\cdot}7$, that is to say, 1° C. has to be reckoned for each 3·7 ohms in H. H is accordingly divided into units of 3·7 ohms, and contains 1 step of 10°, 9 of 1°, and 9 of 0·1° C. It is added to the arm *a* when the temperature of the cable is higher than 15° C., and to the arm *b* when the temperature is lower than 15°. The formula for the resistance *r* of the insulation per kilometre reduced to 15° C. is—

$$r_{15} = 10^5 . \frac{Nz}{nZ} . f^{15-t} . L,$$

using the deflection method, where N = the number of scale divisions through which the galvanometer is deflected when connected to earth through 10^5 ohms with a 100-volt battery. The galvanometer is provided with an Ayrton shunt of which Z ohms are in the main circuit. The 10^5 ohm resistance is then replaced by the core of the cable and the galvanometer deflected through *n* scale divisions, the shunt having *z* ohms in the main circuit. L = the length of the cable in kilometres. This can be simplified by drawing a curve, a rectangular hyperbola, connecting *n* and r_t from the above formula, neglecting the term f^{15-t}, taking r_t as abscissæ and N, *z*, Z as constants for the same cable. On the same paper a number of radius vectors are drawn at angles ε corresponding to different temperatures, where $\tan \varepsilon = r_t : r_{15} = f^{t-15}$, and values of r_t are also taken as abscissæ. This diagram is used as follows: The ordinate corresponding to the observed deflection is found on the hyperbola, and also the corresponding abscissa giving the resistance r_t. From here passing upward the point is found where the ordinate cuts the temperature vector, for example, for 16°, and finds the ordinate to this r_{15}. This can be

left to find r_0, then to pass directly from the hyperbola to the temperature vector, and finally to read off on the axis of y, the resistance of 1 kilometre of cable reduced to 15°. The whole calculation is thus effected graphically. The paper also describes the construction of a slide-rule for performing the above calculation. C. K. F.

498. *Examination of Very Small Charges of Electricity.* **R. Blondlot.** (Comptes Rendus, 133. pp. 717–719, Nov. 4, 1901.)—The apparatus employed consists essentially of a pair of $2 \times 2{\cdot}4$ cm. brass plates, one of which is connected to earth and the other insulated, and having suspended between them by a quartz fibre an insulated needle formed of a bent blade of aluminium. The charge communicated to the insulated brass plate causes a deviation of the needle proportional to the square of the charge. Devices are employed for multiplying the action of the charges. D. H. J.

499. *Wehnelt Interrupter.* **K. R. Johnson.** (Phys. Zeitschr. 3. pp. 105–106, Dec. 15, 1901.)—In a former communication [see Abstract No. 2413 (1901)] the author showed how to arrive at an expression for the periodicity of the Wehnelt interrupter, in terms of the length of the circuit, the velocity of light, and the "dielectric constant" of the medium surrounding the platinum electrode. An expression for the periodicity has also been obtained by H. T. Simon [see Abstract No. 1520 (1899)] in terms of the resistance, self-induction, and e.m.f. of the circuit. The author compares his equation with that of H. T. Simon. As, however, the results are not supported by experiment no value can be attached to them. R. A.

500. *Phasemeter for Three-phase Circuits.* **R. Arnò.** (Elettricità, Milan, 20. pp. 755–756, Nov. 30, 1901. Abstract of a paper read before the Associazione Elettrotecnica Italiana.)—The author describes a modification of the method suggested by him of measuring the phase-difference in three-phase circuits by means of an ordinary wattmeter. If a, b, and c represent the three conductors of the circuit, in the original method, the current coil is inserted in circuit a, and the pressure coil joined first between a and the neutral point, and then between b and c; the ratio of the two readings then gives $\sqrt{3} \tan \phi$. The modification consists in having the pressure coil wound double. One coil is joined between a and b, and the other first between a and c, and then between c and a, the two being in series in each case. The centre of the coil is then at the same pressure as the current coil, and, if the greater part of the pressure be absorbed in external resistances, there is no large difference of potential in the instrument. G. H. B.

501. *The Lloyd-Creak Dip-Circle.* (Terrestrial Magnetism, 6. pp. 119–121, Oct., 1901.)—This differs from the Lloyd Circle in certain points of construction and usage as follows: (1) The circle is divided to every 10′, instead of to 15′; (2) the upper half of the jewel bearings is removable, so that either the reversible dip needle or the non-reversible intensity needle may be inserted; (3) a lifter is used when the apparatus is not in action; (4) a ground glass back, when illuminated even by a candle, gives ample light for reading the microscopes; (5) when the instrument rests on the gimbal table, the circle can be readily placed in the magnetic meridian; (6) the weighted needle is pierced for inserting weight in either end of the needle. The instrument is specially intended for high values of the total intensity. Sketches are given. P. E. S.

ALTERNATING CURRENTS AND MAGNETISM.

502. *Action of Direct-current Armatures on Alternating Currents.* **H. Poincaré.** (Écl. Électr. 30. pp. 77–81, Jan. 18, 1902.)—This article has been inspired by the discussion of this subject by Leblanc, Latour, and Heyland [see Abstracts Nos. 80, 334, and 335 (1902)]. Since experiment has shown that Latour is correct, the author examines closely the reasoning of Leblanc. First of all he considers the general theory. Instead of dividing the time into intervals equal to the period of the polyphase current, he takes for his period the time that elapses from the moment a brush leaves a commutator-bar to the moment it leaves the next. He proves that if the number of segments were infinite, and the speed of the armature suitable, then the magnetic field would be absolutely fixed in space. In practice it is not absolutely fixed, but at the end of each period it is in the same position as it was at the beginning of the period. It therefore acts as if it had no appreciable self-inductance. In order to show where Leblanc's reasoning is incorrect he points out that two separate cases have to be considered in each period. In the first place the brush rests on one commutator-bar and in the second the act of commutation takes place. In the first, as Leblanc mentions, the field turns round with the armature, but in the second, which is very brief, it is brought back to its original position. A. R.

503. *Demagnetising Factors of Cylindrical Rods.* **C. Benedicks.** (Ann. d. Physik, 6. 4. pp. 726–740, Dec. 5, 1901.)—The demagnetising factors of cylindrical rods cannot be determined theoretically, as is possible for ellipsoids of rotation; the author has made experiments to determine them, employing both magnetometric and ballistic methods. The experiments were confined to a single specimen of cast steel, 20 cm. long by 0·8 cm. diameter, the dimension ratio being therefore 25. Curves of I and H were taken by magnetometric and ballistic methods; in the latter I was calculated from the formula $I = (B - H)/(4\pi - N)$, where N is the almost negligible demagnetising factor at the centre of the bar. The ratio of the intensities of magnetisation found by the tried methods respectively increased from 0·687 at H = 23 to 0·84 at H = 206. The rod was then turned down to an ellipsoid of rotation; measurements taken before and after annealing showed that the turning had no appreciable effect on the magnetic properties. The IH curve was taken by the magnetometric method, and the shearing curves drawn for the two curves of the cylindrical rod. That for the ballistic curve is a straight line to I = 800, giving a demagnetising factor of 0·0444; the value given by Du Bois for the dimension ratio 25 is 0·0533. At higher magnetisations, the demagnetisation diminishes rapidly and finally vanishes. The shearing curve for the curve obtained by the magnetometric method is also a straight line to I = 700, giving a demagnetising factor of 0·0658; Maun's value for soft iron of the same dimension ratio is 0·0648. At higher magnetisations the demagnetisation increases very rapidly. The difference between the demagnetising factors applicable to measurements made by magnetometric and ballistic methods, is due to the fact that in the former case the field strength is corrected to the mean value for the whole cylinder, while in the latter it is corrected to the maximum value in the centre of the cylinder. Du Bois' values of the demagnetisation factors were derived from Ewing's ballistic measurements for dimension ratios above 50, and from Tanakadaté's magnetometric measurements for ratios below 50. The latter are too high when referred to ballistic measurements, and too low when referred to magnetometric. G. H. B.

504. *Residual Magnetism in Different Steels.* **A. Abt.** (Ann. d. Physik, 4. pp. 774–783, Dec., 1901. Paper read before the Siebenbürger Museum-Vereins, Feb. 22, 1901.)—The paper gives measurements, made on a large number of rods of different kinds of hardened steel, of their permanent magnetic moments after magnetisation in fields of different strengths. The magnetic moments are expressed in arbitrary units. The steel having the greatest moment was a nickel-chrome steel, followed, in order of decreasing moments, by chrome steel, nickel steel, tungsten steel, carbon steel, and manganese steel. The magnetic moment and the intensity of magnetisation decreases with the length of the rod. The rods were sent for exhibition to the Paris Exhibition, and measurements made on their return showed a large decrease in moment, from 25 per cent. to 35 per cent. in the case of the nickel and chromium steels, while in the case of the tungsten steel the moment decreased from 53·6 to 1·0. Demagnetising curves are given between the demagnetising field and the moment. The moment could be increased to nearly the same value in the opposite sense. Strong magnetisation of a rod of limonit ($2Fe_2O_3 + 3H_2O$) gave a hardly perceptible moment. G. H. B.

505. *Magnetic Declination and Inclination in France.* **E. Mathias.** (Archives Néerlandaises, 6. pp. 412–429, 1901. Also Comptes Rendus, Nov. 25, 1901.)—The author has already adduced a linear formula to represent the horizontal intensity throughout France in terms of latitude and longitude [see Abstract No. 1130 (1901)]. This was done by taking the region of Toulouse as his normal region, and using, for the rest of France, the data of Moureaux in his Magnetic Report for 1896. In the case of the declination and inclination, however, the corresponding formulæ are more complex, being of the second degree, and containing five or six terms.

The expression for declination is :—

$$\Delta D = 0{\cdot}42\ (\Delta \text{ long.}) + 0{\cdot}17\ (\Delta \text{ lat.}) + 0{\cdot}00009\ (\Delta \text{ long.})^2 + 0{\cdot}000086\ (\Delta \text{ long.})\ (\Delta \text{ lat.}) - 0{\cdot}000062\ (\Delta \text{ lat.})^2$$

Here ΔD stands for the difference between the declination of any given station and that of Toulouse, in terms of Δ (long.) and Δ (lat.), the differences between the longitudes and latitudes respectively of the two stations. A somewhat similar expression is given for the inclination. Tables are given showing that the formulæ represent facts very closely, both on the coast and inland : thus for more than 300 stations the differences in declination are less than 3′. Disturbed regions are found in various places but they do not affect the general law for the whole country. P. E. S.

REFERENCES.

506. *Circuit-breakers.* **H. Denis.** (Électricien, 22. pp. 359–361, Dec. 7 ; 372–374, Dec. 14 ; and pp. 392–395, Dec. 21, 1901.)—The paper describes some forms of circuit-breakers for use with induction coils, manufactured by Lecarme Frères and Michel. G. H. B.

507. *König's Manometric Flames for Studying Changes in Wave-form of Alternating Currents.* **R. Weber.** (Archives des Sciences, 12. pp. 602–608, Dec., 1901. Paper read before the Société Helvétique des Sciences Naturelles, Aug. 6, 1901, at Zofingue.) This is a paper on the same lines as the one dealt with in Abstract No. 81 (1902).

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

508. *A New Element in Thorium.* **C. Baskerville.** (Chem. News, 81. pp. 179–181, Oct. 11, and pp. 187–189, Oct. 18, 1901. Paper read at the Denver meeting of the American Chemical Society, Aug. 27, 1901.)—Pure thorium, from pure thorium tetrachloride, has an atomic weight of no more than about 223·3. Ordinary pure thorium, from monazite sand, contains a radio-active element whose atomic weight (if it be tetravalent) lies between 260 and 280; carolinium, Cn. A. D.

509. *Thermochemistry of Compounds of Aluminium Chloride with Alkaline Chlorides.* **E. Baud.** (Comptes Rendus, 133. pp. 869–871, Nov. 25, 1901.)—The heat of formation of $Al_2Cl_6.2NaCl$ sol., is 11·8 cal., of the corresponding potassium compound 26·38 cal., of the ammonium compound 26·53 cal. The bodies, $Al_2Cl_6.3NaCl$, $Al_2Cl_6.6NaCl$, and the corresponding potassium compounds—here described for the first time—are in accordance with their heats of formation, very probably definite compounds. D. H. J.

510. *Sulphuric Acid and its Manufacture by the Contact Process.* **R. Knietsch.** (Ber. Deutsch. Chem. Gesell. 34. pp. 4069–4115, Dec. 28, 1901.)—Sulphuric acid is now manufactured on a large scale by the direct combination of sulphur dioxide and oxygen in presence of spongy platinum. The sulphur dioxide is prepared by burning pyrites, but extraordinary care has to be taken to free it from arsenic, which immediately destroys the activity of the platinum. The output of sulphuric anhydride in 1900 amounted to 116,000 tons. The interaction begins at about 200°, and reaches a maximum at about 430°, but is only complete in presence of an excess of oxygen; above 430° decomposition of the sulphur trioxide begins and is complete above 1,000°; the temperature of action is therefore kept below 450°, and in practice 98–99 per cent. of the sulphur dioxide is oxidised. Contrary to all expectation, the absorption of the sulphur trioxide is not readily accomplished by water, but takes place with remarkable readiness when a 96–98 per cent. acid is used; this is in accordance with the fact that the boiling-point of the acid reaches a maximum and the vapour pressure a minimum in an acid containing 98⅓ per cent. H_2SO_4.

A study of the physical properties of the acid shows maxima in the melting-point curve at compositions corresponding to the formulæ $H_2SO_4 + H_2O$, H_2SO_4, and $H_2S_2O_7$, and corresponding minima in the conductivity curve; a minimum conductivity was found by Kohlrausch at 99·74–99·75 per cent. H_2SO_4, but the minimum value now found for acid prepared from pure sulphur trioxide is at 99·9–99·95 per cent., agreeing more exactly with the composition of the monohydrate H_2SO_4. The readiness with which iron is attached by the strong acid corresponds closely with the conductivity of the acid, both reaching a maximum at 12–15 per cent. of free SO_3. The viscosity reaches maxima at concentrations corresponding nearly with the formulæ $H_2SO_4 + H_2O$ and $H_2S_2O_7$, and the capillarity also changes abruptly at the latter point. Points of maximum density occur at 97·66 per cent. H_2SO_4 and at 55 per cent. free SO_3, with a minimum at 99·4 per cent. H_2SO_4. The specific heat of

ne acid reaches a minimum at about 21 per cent. free SO_3, but the heat of solution rises steadily from 0 per cent. to a maximum at 100 per cent. SO_3.

T. M. L.

511. *Formation of Naturally-occurring Anhydrite, and the Rôle of Time in Chemical Transformations.* **J. H. van't Hoff.** (Archives Néerlandaises, pp. 471–489, 1901.)—The first part of the paper gives a summary of the researches carried out in van't Hoff's laboratory, whereby the difficult question of the transformations of calcium sulphate and its hydrates has been elucidated. The special methods required for the solution of this problem are described in detail. Gypsum, $CaSO_4.2H_2O$, in contact with saturated solution, is transformed into the semihydrate, $CaSO_4\frac{1}{2}H_2O$, at a temperature of 107·2 (pressure = 970 mm.), *i.e.*, we have—

$$107{\cdot}2^\circ\text{C.}.2CaSO_4.2H_2O \rightleftarrows (CaSO_4)_2.H_2O + 3H_2O.$$

The remarkable fact has been ascertained that the semihydrate obtained under these conditions is, in reality, an unstable or metastable form, for gypsum is converted (in contact with saturated solution) into an *anhydrous* form at a temperature below 100° C., that is to say, the transition-temperature corresponding to the equilibrium

$$CaSO_4 2H_2O \rightleftarrows CaSO_4 + 2H_2O,$$

lies below 100° C., and hence the semihydrate at the temperature of its formation, as given above, tends to decompose as follows :—

$$2(CaSO_4)_2.H_2O = CaSO_4.2H_2O + 3CaSO_4.$$

The *anhydrous* calcium sulphate referred to here is not the natural anhydrite, but a more soluble, and therefore itself unstable, form. This soluble form can be obtained by hydrating ordinary plaster-of-Paris, which is simply the semihydrate, with an excess of water, filtering, drying, and heating at 100° C. As this soluble form is unstable with respect to the insoluble (naturally-occurring) form, it follows that the latter will be produced from gypsum at a still lower temperature. Experiments indicate that this transition-point, in presence of saturated sodium chloride solution, lies about 30° C. This explains fully the occurrence of anhydrite in the natural oceanic deposits studied by van't Hoff. The difficulties encountered in the study of calcium sulphate are due to the slowness with which certain forms are produced and certain equilibria attained. In the second part of the paper van't Hoff is led to a generalisation on this point. *The sluggishness increases as the valency of either the metal or the anionic group increases.* Numerous instances are quoted in support of this view. A very striking instance is the case of thorium sulphate, where the speed of reaction is remarkably small. The same general law is observed to hold in the case of the free non-metallic elements. Thus in the series of elements oxygen, sulphur, phosphorus, carbon, the unstable forms exhibit an increasing degree of "false equilibrium" as the valency increases, *i.e.*, the speed of change into the stable form diminishes. Finally van't Hoff points out that it is this characteristic, exhibited in an eminent degree by carbon, which gives to organic chemistry its peculiar character. If all the essentially unstable isomers, polymers, &c., of organic chemistry were to be eliminated, there would be comparatively few compounds left. [See also Abstract No. 1721 (1901).] F. G. D.

512. *Formation of Oceanic Salt-deposits. Separation of Kieserite at 25°.* **J. H. van't Hoff, W. Meyerhoffer,** and **N. Smith.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 42. pp. 1034–1044, Oct. 31, 1901.)—The hydrate $MgSO_4.12H_2O$ passes, at 1·8°, into the common hydrate $MgSO_4.7H_2O$, and this, at 48·2°, into the hexahydrate $MgSO_4.6H_2O$. Above a temperature lying between 67° and 68° kieserite, $MgSO_4.H_2O$ is the stable hydrate, but the hydrates $MgSO_4.5H_2O$ and $MgSO_4.4H_2O$ can also exist in a labile condition above 77½°; the existence of the hydrate $4MgSO_4.5H_2O$ as a hydrate distinct from kieserite is not fully established. Kieserite is also formed at ordinary temperatures by the action of dehydrating agents on the other hydrates. At 25° $MgSO_4.7H_2O$ and $MgSO_4.6H_2O$ are in equilibrium together when in contact with a solution of the composition $1000H_2O$, $62½MgSO_4$, $116HNO_3$, the hydrates $MgSO_4.6H_2O$ and $MgSO_4.4H_2O$ are in equilibrium with a solution of the composition $1000H_2O$, $67MgSO_4$, $140½HNO_3$, and the hydrate $MgSO_4.6H_2O$ and kieserite are in equilibrium with a solution of the composition $1000H_2O$, $65½MgSO_4$, $132HNO_3$. Magnesium chloride has a dehydrating action similar to that of nitric acid, the hydrates $MgSO_4.7H_2O$ and $MgSO_4.6H_2O$ are in equilibrium together at 25° with a saturated solution of common salt containing $1000H_2O$ to $12MgSO_4$, $67½MgCl_2$, $4Na_2Cl_2$, the hydrates $MgSO_4.6H_2O$ and $MgSO_4.4H_2O$ with a saturated salt solution containing $1000H_2O$ to $8½MgSO_4$, $85MgCl_2$, $1½Na_2Cl_2$, and the hydrate $MgSO_4.6H_2O$ and kieserite with a solution containing $1000H_2O$ to $9½MgSO_4.79MgCl_2$ and $2½Na_2Cl_2$. The conditions of equilibrium are then considered in solutions containing $MgSO_4$, $MgCl_2$, K_2Cl_2, Na_2Cl_2, and lastly in solutions saturated with salt and containing sulphate and chloride of potassium in addition to sulphate and chloride of magnesium. [See further Abstract No. 1538 (1901).] T. M. L.

513. *Production of Optically Active Compounds from Inactive Substances.* **J. B. Cohen** and **C. E. Whiteley.** (Chem. Soc., Journ. 79. and 80. pp. 1305–1312, Dec., 1901.)—This paper describes an attempt to produce a new asymmetric carbonatom in an already active compound from which the originally active group could be subsequently detached, in order to ascertain the influence of the active part of the original molecule on the activity of the new group. The methods adopted were the reduction, bromination, or hydroxylation of esters composed of an unsaturated acid and an active alcohol, and the reduction of a ketonic ester of an active alcohol, the alcohol being afterwards removed by hydrolysis, but in all cases negative results were obtained. Amyl cinnamate and several menthyl esters were examined and their optical properties given. S. R.

514. *Coloration of Crystalline Haloid Salts by means of Potassium or Sodium Vapour.* **G. C. Schmidt.** (Phys. Zeitschr. 3. p. 115, Dec. 15, 1901.)—This coloration, described by Giesel (Ber. Deut. Chem. Gesell., 1897, 156–158), can be readily seen by packing sodium or potassium chloride in a tube of difficultly fusible glass, one end of which is blown out into a bulb in which sodium or potassium is heated to boiling, whilst the other end is connected with an air-pump. When the vapours of the metal come into contact with the salt, the beautiful blue colour of the subchloride makes its appearance. The carbonates of sodium and potassium remains unchanged when submitted to this treatment. T. H. P.

515. *Alloys of Aluminium and Magnesium.* **O. Boudouard.** (Comptes Rendus, 133. pp. 1003–1005, Dec. 9, 1901.)—Three compounds of aluminium

nd magnesium have been isolated by extracting with various solvents a eries of alloys of the two metals in different proportions. $AlMg_3$ forms borescent crystals and has specific gravity 2·03; AlMg has specific gravity ·15; Al_4Mg has density 2·58. T. M. L.

516. *Condition of the Silicon in Iron Castings.* **P. Lebeau.** (Comptes rendus, 133. pp. 1008–1010, Dec. 9, 1901.)—From mixtures of iron, silicon, nd copper three definite silicides of iron were isolated, having the formulæ Fe_2Fe, SiFe, and $SiFe_2$. Si_2Fe is only formed in presence of a very large xcess of silicon, and would never occur in an iron casting. SiFe was also ound to be readily dissociable, according to the equation $2SiFe = SiFe_2 + Si$, nd was almost entirely decomposed by crystallising from silver, *i.e.*, by issolving in silver and extracting the silver with nitric acid; it would not herefore exist in presence of an excess of iron. $SiFe_2$, on the other hand, is xceedingly stable, and can be recovered entirely unchanged after crystallising rom silver; it is therefore probable that the whole of the silicon in iron astings is in this form. SiFe is non-magnetic, but $SiFe_2$ is magnetic.
T. M. L.

517. *Liquid Nitrogen Peroxide as a Solvent.* **P. F. Frankland** and **R. C. Farmer.** (Chem. Soc., Journ. 79. and 80. pp. 1356–1373, Dec., 1901.)—When used as a solvent, nitrogen peroxide shows an unexpected resemblance o the common organic solvents, such as benzene and ether, rather than to the norganic solvents. Thus in no single instance were inorganic salts found to e soluble in it, whilst organic compounds dissolved freely; in most cases the olubility of the substances in liquid nitrogen peroxide resembled their olubility in ether, but a few substances insoluble in ether were found to issolve in liquid nitrogen peroxide. When dry and free from lower oxides f nitrogen, the peroxide is remarkably inert, cane-sugar being soluble ithout decomposition; hydroxy- and amino-compounds are, however, usually ttached. Dry liquid nitrogen peroxide is a non-conductor; when no special recautions were taken to remove all traces of water, the liquid had a specific onductivity 0·1 to $0·2 \times 10^{-6}$, the minimum value for water distilled in air eing $0·65 \times 10^{-6}$; but by adding phosphorous pentoxide the conductivity as reduced so far as to be unmeasurable. When mixed with 2 per cent. of ater the conductivity is as great as that of N/100 HNO_3, but dry solutions in itrogen peroxide of hydrogen chloride and of a number of organic acids ere found to be non-conductors. In the case of eight neutral substances he molecular elevation of the boiling-point was found to be 13·7° C. for gram-mol. of the substance per 100 grams of solvent. Benzoic acid, the hree toluic acids, acetic, tribromacetic and trichlorobutyric acids were found o be associated more or less completely to double molecules—a mode of ehaviour which is characteristic also of solutions in benzene of organic acids; initrophenol and picric acid gave normal values for the molecular weight.
T. M. L.

518. *Solubility of Silver Bromide and Silver Iodide in Water.* **F. Kohlrausch** and **F. Dolezalek.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 41. p. 1018–1023, Oct. 24, 1901.)—The determination of the solubility of silver romide and iodide by means of conductivity measurements presents unusual ifficulties, owing to the extraordinary smallness of the quantities measured; hus the effect of breathing close to the conductivity vessel raises the conuctivity of the water to an extent as great as that produced by saturation

with silver bromide, and forty times as great as that produced with silver iodide. All the previous determinations that have been made have given results many times greater than those now recorded. Pairs of experiments with water saturated with silver bromide, starting from higher and from lower temperatures, gave an increase of conductivity of $0{\cdot}075 \times 10^{-6}$ units, at 21·1°, corresponding to the dissolution of $0{\cdot}57 \times 10^{-6}$ gram-equivalents or 0·107 mg. AgBr per litre. In the case of silver iodide it was found that satisfactory measurements could best be made by pouring the water on to silver iodide and determining its conductivity before and after it had been saturated by shaking. The increase in conductivity was only $0{\cdot}0020 \times 10^{-6}$ units at 20·8°, corresponding to the dissolution of $0{\cdot}015 \times 10^{-6}$ gram-equivalents or 0·0035 mg. per litre. The solubility of silver bromide and iodide has also been deduced in accordance with Nernst's law from the e.m.f. of concentration cells, and, although the values obtained by different observers differ considerably, they are all of the same order of magnitude as those now recorded, and values which are practically identical with these have been obtained by two observers in the case of each of the two silver haloids. T. M. L.

519. *Dilution Constant of Saline Solutions.* **A. Colson.** (Comptes Rendus, 133. pp. 1207–1209, Dec. 23, 1901.)—The author's previous experiments [see Abstract No. 120 (1902)] appeared to indicate that the critical temperature shown to exist in the case of some salts, at which there is no thermal change on dilution, depends only on the nature of the solvent and the dissolved substance; and not at all on the state of dilution. The author confirms this by experiments on solutions of common salt, varying in concentration from a completely saturated solution to a tenth of that amount, the fixed temperature being now determined by the following method: 100 cub. cm. of a saturated solution of the salt are sealed in a bulb and placed in a calorimeter containing 400 cub. cm. of distilled water and surrounded by a bath of constant temperature. The bulb is then broken, and the change of temperature noted. When the alterations of temperature are taken as ordinates, and the temperatures of the bath as abscissæ; the resulting curve is nearly rectilinear, and cuts the axis of abscissæ at the desired point. This temperature is 52° C. for NaCl; 64°·5 C. for KCl; 116° C. for $NaNO_3$; 122° C. for KNO_3. The two last values are obtained by interpolation. W. C. B.

520. *Plaitpoint Curves in Ternary Systems.* **F. A. H. Schreinemakers.** (Archives Néerlandaises, 6. pp. 170–192, 1901.)—Four curves are discussed: (1) For critical fluids of the first order at constant pressure; (2) for critical fluids of the first order at constant temperature; (3) for critical fluids of the first order under their own vapour pressure; (4) for critical fluids of the second order. When, at definite temperature and pressure, two plaitpoints occur on the binodal curve, there corresponds to each a critical solution, called a critical fluid of the first order. When, for a change of temperature or pressure, the binodal curve diminishes and the solutions of the first order have more nearly the same composition, the plaitpoints ultimately coincide in a double plaitpoint, and the corresponding solution is called a critical solution of the second order. It is pointed out that a critical solution of the second order may also arise, as previously obtained experimentally, from the occurrence of two binodal curves with a plaitpoint on each, which ultimately coincide as pressure and temperature are changed. The various analytical conditions

r the critical fluids, and the differential equations of the curves, are veloped. In particular the equation—

$$\frac{dT}{dx} = \frac{\frac{\partial l}{\partial x} - \frac{s^2}{RT}}{\frac{\partial^2 \eta}{\partial y^2}}$$

found to determine whether the temperature, at which two fluid layers come identical, rises or falls when a third component is added. W. E. T.

521. *Formation of Ozone.* **A. Chassy.** (Comptes Rendus, 133. pp. 789–91, Nov. 11, 1901.)—The author gives the results of a study of the proportions of ozone formed on passing an electric discharge for varying times through a definite mass of oxygen, the current being meanwhile maintained constant. The increase in the proportion of ozone follows the same law, no matter what the intensity of current employed. Further, a feeble current can always produce the same effect as one more intense, provided its time of action be sufficiently great, or, if an apparatus for continuous production be used, provided the flow of gas is sufficiently slow. The following numbers are for 20°, the unit of time being that necessary for the transformation into ozone of 0·5 per cent of the oxygen :—

Time.	Quantity of Ozone.	Time.	Quantity of Ozone.
1	5	10	31·5
2	9·1	12	34·5
3	12·7	14	37·4
4	16·1	20	44
5	19·2	36	54
6	22·2	60	64·5
7	25	90	70·5
8	27·2	120	73

The curve representing these results is asymptotic to the time axis; the quantity of ozone tends towards a limiting value which depends only on the temperature and not on the current intensity, but which is difficult to determine accurately. It is seen from the above table that to obtain oxygen containing 70 parts per 1,000 of ozone costs ninety times as much as to prepare oxygen with 5 parts of ozone per 1,000. Considering only the expenditure of electrical energy, it is economical to only feebly ozonise the oxygen and to promote the active circulation of the gas. T. H. P.

522. *Specific Inductive Capacity of Solvents.* **H. Schlundt.** (Journ. Phys. Chem. 5. pp. 503–526, Oct., 1901. Printed in full in the Univ. Wisconsin, Bull., Science Series, 1901.)—In 1893 Nernst [Gott. Nach. No. 12 (1893), also Zeit. Phys. Chem. 13,531 (1894)], gave the rule that, other things being equal, the greater the specific inductive capacity of a medium the greater is its dissociating power. J. J. Thomson also pointed this out, saying that, if the forces between the atoms are electrical, then the effect of surrounding the molecules of a substance by a medium possessing very high specific inductive capacity like water would be to dissociate them. The following important tables are given :—

Name.	Formula.	Boiling Point.	Atmospheric Pressure mm. of Hg.	Temperature (Centigrade).	Specific Inductive Capacity.
Methylamine	CH_3NH_2	—	—	<10·5	21
Ethylamine	$C_2H_5NH_2$	<17·5	752	6·17	21
Isopropylamine	$(CH_3)_2CHNH_2$	36	750·5	5·45	20
Butylamine (*n*)	$C_4H_9NH_2$	76–77	740·0	5·30	21
Isobutylamine	$(CH_3)_2CHCH_2NH_2$	68	745·2	4·43	21
Amylamine	$C_5H_{11}NH_2$	94–95	740·4	4·50	22
Diethylamine	$(C_2H_5)_2NH$	54·5	733·4	3·58	21
Dipropylamine	$(C_3H_7)_2NH$	108-108·5	745·5	2·90	22
Diisobutylamine	$[(CH_3)_2CHCH_2]_2NH$	134.5	735·0	2·65	22
Trimethylamine	$(CH_3)_3N$	<8	750	2·95	4
Aniline	$C_6H_5NH_2$	179·4	741	7·2	18·5
Toluidine (*o*)	$C_6H_4<\begin{matrix}CH_3\\NH_2(o)\end{matrix}$	194·5	738·0	5·93	20
Toluidine (*m*)	$C_6H_4<\begin{matrix}CH_3\\NH_2(m)\end{matrix}$	194·2	738·2	5·95	20
Xylidine 1 : 3 : 4	$C_6H_5<\begin{matrix}CH_3\ 1\\CH_3\ 3\\NH_2\ 4\end{matrix}$	209·5	737·0	4·90	20
Monomethylaniline	$C_6H_5NHCH_3$	189·4	740·5	5·8	20
Dimethylaniline	$C_6H_5N(CH_3)_2$	191·5	735·0	5·07	20
Dibenzylamine	$(C_7H_7)_2NH$	200	40·0	3·55	20
Nitromethane	CH_3NO_2	99·9	738·4	40·4	19
Nitroethane	$C_2H_5NO_2$	110·5	738·3	29·5	18
Methyl nitrate	CH_3NO_3	64·4	730·2	23·5	18
Ethyl nitrate	$C_2H_5NO_3$	86·1	729·4	18·3	18
Propyl nitrate	$C_3H_7NO_3$	108·5	738·5	13·9	18
Isobutyl nitrate	$(CH_3)_2CHCH_2NO_3$	120·0	738·2	11·7	19
Isopropyl nitrite	$(CH_3)_2CHNO_2$	—	—	11·5 ?	18
Ethyl urethane	$CO(NH_2)(OC_2H_5)$	—	—	13·6	60
Ethyl urethane (solid)	—	—	—	3·18	23
α-Picoline	$(C_5H_4N.CH_3(\alpha)$	128·5–129·5	736	9·8	20
Piperidine	$C_5H_{11}N$	105·5–107	745	5·8	20
Carbon dichloride	C_2Cl_4	118	726·5	2·46	21
Amylsulphydrate	$C_5H_{11}SH$	116·5	752	4·35	22
Ethylene cyanide	$C_2H_4(CN)_2$	168	28	61·2	60
„ „ (solid)	„	—	—	65·3	23
α-Naphthonitrile	$(C_{10}H_7CN(\alpha)$	—	—	16·0	70
„ (liquid)	„	—	—	17·9	42
„ „	„	—	—	19·2	22
„ (solid)	„	—	—	6·3 ?	21
β-Naphthonitrile	$C_{10}H_7CN(\beta)$	190	35	16·9	70
„ (solid)	„	—	—	4·3	22
Mandelic nitrile	$C_6H_5CH<\begin{matrix}OH\\CN\end{matrix}$	94	50	17·82	23
Phosphorus trichloride	PCl_3	74·1	740	3·36	22
Arsenic „	$AsCl_3$	127–128	740	12·35	21
Antimony „	$SbCl_3$	—	—	33·2	75
„ „ (solid)	„	—	—	5·4	18
Antimony pentachloride	$SbCl_5$	—	—	3·78	21·5
Stannic chloride	$SnCl_4$	117·5	750	3·2	22
Sulphur monochloride	S_2Cl_2	136·2	738	4·8	22
Sulphur dioxide	SO_2	—	—	12·35	22
Sulphur trioxide	SO_3	—	—	3·56	21
„ „ (solid)	„	—	—	3·64	19
Sulphuryl chloride	SO_2Cl_2	68·4	740·2	9·15	22
Thionyl	$SOCl_2$	76·8	751·3	9·05	22
Phosphorus oxychloride	$POCl_3$	105·1	739·2	13·9	22
Cyanogen	$(CN)_2$	—	—	2·52	23
Bromine	Br	—	—	3·18	23
Iodine (solid)	I	—	—	10·3 ?	23

The principal points in the paper are :—

(1) The values of the dielectric constants for the homologous series of compounds examined decrease with increase of molecular weight. (2) The introduction of the cyanogen group in a compound causes a marked increase in the value of the dielectric constant. In this respect the cyanogen radical produces a greater effect than all other radicals which have hitherto been systematically studied. (3) The cyanogen (CN), amido (NH_2), or nitric acid (NO_3) radicals, when present in compound, do not cause anomalous absorption, which Drude found for the hydroxyl (OH) group. (4) A number of new examples are given which follow the Nernst-Thomson rule. (5) Some striking exceptions to the Nernst-Thomson rule are pointed out, from which it has been argued that the rule is inadequate. The exceptions indicate that the nature of the solvent, as well as the dissolved substance, are of primary importance in determining whether a solution will conduct electricity. (6) Obach's law holds only approximately for the nitriles. [See also Abstract No. 1358 (1901).] M. O'G.

523. *Effect of Low Temperatures on Voltaic Cells.* **L. Bleekrode.** (Archives Néerlandaises, 6. pp. 448–454, 1901.)—The author placed cells (a copper oxide cell, and a secondary cell) in a bath of solid carbon dioxide dissolved in acetone. Values of the e.m.f. and internal resistance are given for various temperatures down to $-65°$, apparently without the condition of the cell being constant. The general effect of lowering of temperature is to diminish the e.m.f. and to raise the internal resistance. W. R. C.

524. *Influence of Temperature on Conductivity of Solutions and Mobility of Ions in Water.* **F. Kohlrausch.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 42. pp. 1026–1033, Oct. 31, 1901.)—The influence of temperature on the electrical conductivity of solutions may be represented by the formula—

$$\kappa_t = \kappa_{18}[1 + \alpha(t-18) + \beta(t-18)^2].$$

From observations in the case of dilute solutions the temperature coefficients may be deduced for infinitely dilute solutions. These are shown in the following table :—

Solution.	α	β	Solution.	α	β
HNO_3	0·0163	− 0·000016	K_2SO_4	0·0222	+ 0·000077
HCl	0·0164	− 0·000015	PbN_2O_6	0·0224	+ 0·000078
H_2SO_4	0·0165	− 0·000017	$BaCl_2$	0·0225	+ 0·000083
H_3PO_4	0·0169	− 0·000001	NaCl	0·0226	+ 0·000084
KOH	0·0190	+ 0·000032	$SrSO_4$	0·0228	+ 0·000084
KNO_3	0·0210	+ 0·000062	Na_2SO_4	0·0233	+ 0·000097
KI	0·0212	+ 0·000058	$MgSo_4$	0·0238	+ 0·000095
$AgNO_3$	0·0216	+ 0·000067	$NaHC_4H_4O_4$	0·0241	+ 0·000109
KCl	0·0217	+ 0·000067	NaF	0·0242	+ 0·000102
NH_4Cl	0·0219	+ 0·000068	$NaC_2H_3O_2$	0·0242	+ 0·000110
$NaNO_3$	0·0220	+ 0·000075	$NaC_5H_9O_2$	0·0243	+ 0·000111
BaN_2O_6	0·0220	+ 0·000075	Na_2CO_3	0·0262	+ 0·000151
KF	0·0222	+ 0·000079			

As α increases β is seen to increase regularly from a small negative value in the case of the acids, to a large positive value, and the relationship between the constants may be expressed, within the limits of experimental error, by

the formula $\beta = 0{\cdot}0163(\alpha - 0{\cdot}0174)$. The change of conductivity with temperature may then be expressed by means of a single arbitrary constant, since β can be calculated when α is known. When $\alpha = 0{\cdot}0174$ then $\beta = 0$ and the conductivity-temperature curve is a straight line. The two constants in the above formula are nearly equal, and the experimental results may be represented with only slightly less accuracy by the formula $\beta = 0{\cdot}0177\ (\alpha - 0{\cdot}0177)$. According to this formula, the conductivity of all salts would cease at $-39°$ C., whilst the more accurate formula gives a variation in the "conductivity zero" of $\pm 2°$ according to the nature of the salt. The frictional constant η of water can be represented by the formula $\eta = 2{\cdot}989\ (t + 38{\cdot}5)^{-1{\cdot}10}$ c.g.s. units; it would therefore appear that at $-39°$ the water would entirely lose its fluidity, apart from crystallisation, and a ready explanation of the "conductivity zero" of aqueous solutions is thus afforded.

In the case of incompletely dissociated solutions the relationship between β and α is less exact, but has a remarkably wide range; a fair agreement appears in the extreme case of $KHSO_4$ (5 per cent.) where α is only 0·0095, and also in the case of sulphuric acid where α changes from 0·0125 in a 5 per cent. solution to 0·0345 in an 84·5 per cent. solution (H_2SO_4, H_2O) whilst β changes in the normal way from $-0{\cdot}000052$ to $+0{\cdot}000297$. Knowing the mobility of the ions at 18°, and the transportation-value of one salt at some other temperature, the temperature-coefficients of the separate ions can be deduced, and are given in the following table:—

Ion.	l_{18}	α	β	Ion.	l_{18}	α	β
H	318	0·0154	−0·000033	F	45·5	0·0232	+0·000094
OH	174	0·0179	+0·000008	IO_3	33·9	0·0233	+0·000096
NO_2	61·8	0·0203	+0·000047	$C_2H_3O_2$...	34	0·0236	+0·000101
I	66·4	0·0206	+0·000052	½Ba	57	0·0239	+0·000106
ClO_3	57	0·0207	+0·000054	½Cu	49	0·0240	+0·000107
Cl	65·4	0·0215	+0·000067	½Pb	61·5	0·0244	+0·000114
Rb.....	67·9	0·0217	+0·000069	Na.....	43·5	0·0245	+0·000116
K	64·7	0·0220	+0·000075	½Mg	46·0	0·0255	+0·000132
NH_4	63·7	0·0223	+0·000079	½Zn	46	0·0256	+0·000133
½SO_4	69	0·0226	+0·000084	Li	33·4	0·0261	+0·000143
Ag.....	54·7	0·0231	+0·000093	½CO_3	(70)	(0·0269)	+(0·000155)
½Sr	53	0·0231	+0·000093				

Amongst the univalent kations H, Rb, K, NH_4, Ag, Na, Li, the simple temperature coefficient α is itself dependent in a regular way upon the mobility of the ion, and can be calculated within the limits of experimental error from the formula $\alpha - 0{\cdot}0065 = 0{\cdot}0683 \left(\frac{1}{l}\right)^{0{\cdot}3515}$; for these substances, therefore, one independent constant only is needed to determine the mobility at all temperatures. T. M. L.

525. *Transport of Liquids by Electric Current.* **E. van der Ven.** (Archives Néerlandaises, 6. pp. 127–132, 1901.)—In the papers by G. Wiedemann and C. Freund on this subject (Ann. d. Physik, 163. p. 321, and 243. p. 44) there is no reference to the part played by hydrostatic pressure, due to the continuously increasing difference between the densities of the solution on the two sides of the porous membrane, the solution in the division containing the kathode becoming the lighter. The author used a solution of 10 parts crystallised sulphate of copper to 100 of distilled water: its density was

·064. Using a 2-volt accumulator, he found that the quantities of liquid passing steadily increased, while the strength of the current fell off somewhat. Making a control experiment with a hydrostatic pressure corresponding to the difference of density between the two parts of the solution he found, making into account the gradual divergence between the two densities, that out of say 33 grms. of liquid driven through by the current, say 8 were driven by the hydrostatic pressure. A. D.

526. *Determination of Ionic Velocities in Aqueous Solutions.* **R. Abegg.** (Phys. Zeitschr. 3. pp. 124–125, Dec. 15, 1901. Paper read before the 73rd Naturforscherversammlung at Hamburg, 1901.)—The method of B. D. Steele [see Abstract No. 1555 (1901)], whose theory had been developed by F. Kohlrausch and H. Weber, gives good results for simple salts like the alkali haloids, but proves less satisfactory in cases where we have reason to assume the presence of complex ions. The stability of the boundary faces is influenced by various circumstances, which Nernst's theory of liquid galvanic couples seems best able to explain. The author agrees with Steele. H. B.

527. *Electrolytic Reduction of Nitrourea.* **G. W. F. Holroyd.** (Chem. Soc., Journ. 79. and 80. pp. 1326–1331, Dec., 1901.)—Semicarbazide was obtained by electrolysing nitrourea in an aqueous solution of ammonium chloride as electrolyte, using electrodes of varying sizes and of wrought iron, fine or platinum. After interrupting the current the contents of the cell are filtered, the filtrate acidified with HCl, and benzaldehyde added, forming benzylidenesemicarbazide. A table is given showing yield of carbazide under varying conditions of temperature, size, and nature of electrodes, and density of current. With zinc poles an alternating current was employed, the alternator being a modification of a form suggested by Mr. A. G. Vernon-Harcourt some years ago, consisting of a flask connected with a U-tube about half full of mercury. After setting the mercury in oscillation, the movement continues so long as the flask is heated, and thus makes and breaks contact. S. R.

528. *Reduction of Alumina by Calcium Carbide.* **S. A. Tucker** and **H. R. Moody.** (Soc. Chem. Ind., Journ. 20. pp. 970–971, Oct., 1901.)—A charge consisting of 100 grams alumina, 112 grams lime, and 125 grams of coke, was heated for ten minutes in an electric furnace at 150 amperes and 70 volts. In addition to aluminium carbide, which was thus formed, there were also found buttons of metallic aluminium, containing, upon analysis, 99 per cent. of metallic aluminium, the rest consisting of iron and mechanically enclosed carbon.

$$Al_2O_3 + CaC_2 = 2Al + 2CO + CaO.$$

A table, containing the results obtained under varying conditions, is then given. The conclusions drawn from this series of experiments are as follows: (1) Aluminium oxide is not reduced by carbon to any appreciable extent, even when both are heated to the extremely high temperature of the electric arc. (2) The addition of lime and the necessary excess of carbon forms an alkaline earth carbide, which is in turn decomposed, and being a body exothermic on decomposition, it yields up a large number of calories, and thus raises the temperature to such a degree that reduction of the oxide takes place to an appreciable extent. (3) The carbide may be made in a separate fusion, and added to the alumina, with or without carbon, but the presence

of some carbon seems to increase the yield of the metal. The production of the carbide in a separate fusion would, however, be condemned on economic grounds. (4) As regards time, anything over twelve or fifteen minutes is prejudicial to good results, and converts the reduced metal to carbide in amounts increasing directly as the excess over the maximum admissible time increases. (5) Aluminium carbide was found to be produced by the metal, and not the reverse. The whole subject may be summed up as follows: The results obtained favour the use of high amperage and voltage for not more than fifteen minutes. The presence of both carbon and a carbide of an alkaline earth is required. Air should be excluded. Finally, the amount of alumina should be considerably in excess of the theoretical amount of coke.

O. J. S.

529. *Production of Ethylene from Inorganic Sources.* **S. A. Tucker** and **H. R. Moody.** (Soc. Chem. Ind., Journ. 20. pp. 971–972, Oct., 1901.)—The object of the authors' experiments was the production of electric furnace products, such as combinations of carbides, or carbides and silicides, which, when treated with water or dilute acids, would, either directly or by interaction, give off gases differing from the gases when any of these carbides were employed alone. They thought it possible thus to produce ethylene.

As calcium carbide yields C_2H_2, and aluminium carbide CH_4, the authors reasoned that these two carbides, produced simultaneously, and submitted to the action of water, might yield ethylene by interaction in the nascent state. Twelve fusions, carried out under varying conditions, yielded negative results, the gases evolved only consisting of CH_4 and C_2H_2.

Mixed carbides were abandoned in lieu of mixed carbides and silicides.

Barium silicide $Ba\begin{smallmatrix}Si\\ \|\|\\ Si\end{smallmatrix}$, produced simultaneously with $Ba\begin{smallmatrix}C\\ \|\|\\ C\end{smallmatrix}$ in the electric furnace, seemed the most likely bodies to produce, as a secondary product, ethylene. A mixture of 100 grms. witherite, 60 grms. of silica, and 43 grms. of coke, added to a carbide charge of 150 grms. of witherite and 25 grms. of coke, and heated by a current of 150 amperes and 60 volts for seven minutes, yielded a blackish mass, which on treatment with warm water gave off a gas containing from 8 to 15 per cent. of ethylene. On increasing the carbide in the mixture, the yield of ethylene dropped to 2 per cent.

Strontium and calcium employed in lieu of barium, gave rather poorer yields.

O. J. S.

530. *Electrolytic Bleaching Apparatus.* **L. Tailfer.** (Ind. Électrochim. 5. pp. 45–48, 1901.)—The author, after enumerating the disadvantages attending the use of the cells and apparatus for production of bleaching solutions at present in use, describes an improved form devised by himself. In this cell the positive and negative electrodes are formed of platinum wire, and are carried on an ebonite bar or rod fixed at the bottom of the cell. The wires are wound upon this rod as two parallel-spirals, and the distance separating the anode and kathode wires is therefore small.

The cell or tank contains a large number of these ebonite bars, each carrying a positive and negative electrode, and the goods to be bleached are passed through the liquid in the upper portion of the tank while the current is being passed through the spiral electrodes. Two different forms of apparatus are shown in the diagrams accompanying this article, intended for use with hank-yarn and piece-goods respectively. The electrolyte, containing 15–20 grammes salt per litre, can only be used for a certain number of

urs, and is then discharged and a fresh solution charged into the ectrolytic tank.

No tests or details of cost are given by the author. Electrolytic bleaching stated to be little used in France. J. B. C. K.

531. *New Form of Diaphragm Cell for the Electrolytic Production of Alkalies d Chlorine.* **J. B. C. Kershaw.** (Electrician, 48. pp. 125–126, Nov. 15, 01.)—Different types of cells are touched upon by the author, who then oceeds to the subject of the article—the diaphragm cell patented by oore, Allen, Ridlon & Quincy. In many respects it closely resembles e Hargreaves-Bird type of cell, and should the Moore-Allen cell become industrial importance the question of patent validity is almost certain to ise. The advantages claimed for the Moore-Allen are: that no steam required to remove the sodium or potassium hydrate from the kathode, at a fairly concentrated solution is obtained containing little undecomposed lt, and that the design and structure of the cell are simplified by dispensing ith an enclosed kathode department. The author is doubtful whether the cond advantage claimed can be substantiated by the results of actual trial, d concludes by remarking that under the conditions described in the tent specification the economic production of caustic alkali by this cell impossible. O. J. S.

532. *Electrolytic Recovery of Tin from Tin Scrap.* **F. Gelstharp.** (Electro-emist, 1. pp. 276–278, Dec., 1901.)—The process described in this illustrated rticle is protected by Patent No. 2282 of 1901. The process has been sub-itted to practical trial at Manchester, and 60 tons of waste tin-cuttings ave been dealt with by the experimental plant. The dynamo used is a wo-pole machine, generating 1,500 amperes at 5 volts. Only one to two olts are required for working the process. The stripping tanks are f wood 5·0 × 1·8 × 3·6 feet deep. Tinned sheet-iron kathodes 5·0 × 3·0 et are fixed 2 inches from each side of the vat. Wooden crates, 6 × 7 × 36 inches deep, hold 56 lbs. of cuttings when fully harged, and rest on supports 6 inches high in the bottom of each vat. opper conductor bars, dipping into mercury, make electrical contact ith the positive pole of the dynamo. Projecting ends of scrap from the rates are twisted round these. The electrolyte is a 1·25 per cent. solution f commercial hydrochloric acid, free from arsenic, and containing a small ercentage of sulphuric acid. This addition is made to precipitate any lead lloyed with the tin, as lead sulphate.

A crate of 56 lbs. of cuttings can be stripped in half an hour with a current f 15 amperes per square foot density, and an e.m.f. of 1 to 2 volts. The tin s deposited at the kathodes in spongy form. It is removed at intervals by craping, and collecting, as it floats on the surface of the electrolyte. This in sponge is washed, submitted to mechanical pressure, and smelted in a mall reverbatory furnace. If preferred, the spongy tin can be used as node in a second depositing vat, and tin crystals obtained by electro-lisposition.

The crates containing the stripped cuttings are immersed in water, and heir charges are then tipped into tanks containing brown oil of vitrol. olution of the iron occurs with heat, and a neutral solution of ferrous ulphate results. From this, crystalline ferrous sulphate is obtained on tanding. The electrolyte used in the depositing vats loses its strength on

continued use, and fresh acid must be added every fourteen days. Zinc and ferrous chloride, although present with the stannous chloride, are not decomposed by currents of less than 2 volts e.m.f. J. B. C. K.

533. *Electrolysis of Copper Solutions.* **A. Fischer.** (Elektrochem. Zeitschr. 8. pp. 192–193, Dec., 1901.)—The author discusses the composition of electrolytic cyanide baths for depositing bright coatings of copper on iron and zinc plates. He recommends, as giving excellent results, a bath described by Von Pfanhauser (Elecktroplattierung, Galvanoplastik. 4 Aufl. S. 332), containing sodium hydrogen sulphite and normal sodium carbonate. These two salts react in the solution, producing normal sodium sulphite and carbonic acid, so the author recommends a modified bath, in which the chief alteration is the substitution of normal sodium sulphite, for the acid salt and normal carbonate. [See also Abstract No. 143 (1902).] W. C. B.

534. *Aluminium.* **E. Wilson.** (Soc. Arts, Journ. 50. pp. 54–62, Dec. 13, 1901.)—Heroult's cell consists of a square iron or steel box lined with carbon, at the bottom of which is a cast-iron plate connected with the negative pole of the dynamo. The positive pole of the dynamo is connected to a number of carbon rods suspended from overhead, and capable of vertical adjustment. The cell is filled with cryolite, which becomes molten by the passage of the electric current, and then the powdered alumina is fed in continuously as long as the operation proceeds. The potential difference between the terminals of each cell is from 3 to 5 volts, and the current overcomes the chemical affinity of the aluminium oxide, besides heating the electrolyte. The current density is about 700 amperes per square foot of kathode surface, and the working temperature varies from 750° to 850° C. The British Aluminium Company give 1 to 1½ lbs. of aluminium as the quantity obtained per twenty-four e.h.p.-hours. The author gives a series of tests on light alloys, points out the utility of bare aluminium for switchboards, for switches where the inertia of the moving part is important, gives details of the Cowper-Coles and other methods of welding, and suggests the use of aluminium for roofing houses. [See also Abstract No. 961 (1898).] M. O'G.

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535. *Radium.* **W. Marckwald.** (Chem. News, 84. pp. 190–191, Oct. 18, 1901.)—A description is given of a method of separating barium out by fractional crystallisation, leaving radio-active radium in more concentrated solution. A. D.

536. *Metals as Fuel.* **W. Roberts-Austen.** (Nature, 64. pp. 360–364, Aug. 8, 1901. Paper read before the Royal Institution, Feb. 22, 1901.)—The author discusses the heat obtainable by the oxidation of metals, and practical results obtained therefrom, more particularly the Goldschmidt process. W. R. C.

537. *The Chemical Significance of Electrical Methods and Theories.* **W. Nernst.** (Phys. Zeitschr. 3. pp. 63–70, Nov. 15, 1901.)—Paper read before the 73 Naturforscherversammlung at Hamburg.

538. *The Phase-Law of Gibbs.* **C. H. Wind.** (Archives Néerlandaises, 4 pp. 323–331, 1901.)—This is a paper on the same lines as that referred to in Abstrac No. 677 (1900).

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

539. *Bursting of Small Cast-iron Flywheels.* **C. H. Benjamin.** (Mech. Eng. 8. pp. 856–858, Dec. 28, 1901. Paper read before the American Society of Mechanical Engineers, Dec., 1901.)—A description is given, with tables and photographs, of the results of the bursting, by rapid rotation, of some 16 cast-iron flywheels, each 2 feet in diameter. Examples of the results are given below :—

Description of Wheel.	Bursting Speed.		Centrifugal Tension.	
	Revs. per Min.	Feet per Sec.	Pounds per sq. inch.	Total on Rim.
Solid cast-iron rim, 6 arms	3,700	387	14,980	59,000
Rim with 2 flanged joints, 6 arms	1,850	193·6	3,750	14,000
Solid cast-iron rim, 24 steel spokes	4,050	424	17,970	44,000

H. R. C.

540. *Steam Calorimetry.* **C. L. Hubbard.** (Amer. Electn. 13. p. 591, Dec., 1901 ; and 14. pp. 34–35, Jan., 1902.)—The first paper describes the separator calorimeter which is used for ascertaining the percentage of moisture, over saturation, which is carried by steam from a boiler. The calorimeter consists of a separator chamber which is formed by two concentric pipes, the inner and smaller one projecting some distance into the outer one, and being perforated with a number of holes about $\frac{1}{8}$ inch diameter at its lower end. Above the perforations the branch from the outer barrel leads to a condenser, and in the branch pipe there is a diaphragm having in its centre a hole of $\frac{1}{16}$ inch diameter. A gauge glass to show the level of water in the barrel of the separator, which is closed by a drip-cock at the bottom, a branch pipe to the boiler, and one for a steam gauge complete the apparatus. When in use the sudden change of direction and velocity causes the steam to deposit the carried moisture in the barrel, and dry steam passes on through the diaphragm. It may be passed through a second calorimeter in series in order to measure the heat lost by radiation, but in event the dry steam is condensed and measured, and the water collected in the separator being also measured, the percentage of moisture is easily obtained from the formulæ : $x = (W + R)/(W + w)$ and $m = 1 - x = (w - R)/(W + w)$, in which x = the quality of the steam ; m = the proportion of moisture in the steam tested ; W = the weight of dry steam discharged at the exhaust orifice ; w = the weight of water drawn from the calorimeter ; R = the weight of steam condensed by radiation. The throttling calorimeter can be used when the percentage of moisture in steam is less than 3 per cent., but as it acts on the principle of throttling by wire-drawing so that the superheating effect of this throttling may be utilised, a large amount of moisture would prevent any superheating effect being realised. Steam from the steam-pipe is

admitted to the calorimeter chamber by a $\frac{1}{2}$-inch pipe having a stopcock and throttling orifice of $\frac{1}{16}$ inch diameter. The temperature of the steam in this chamber and its pressure are both carefully taken, the pressure in the main steam-pipe being also noted. The equation for the use of this calorimeter is obtained as follows: The heat in 1 lb. of high pressure dry steam is $xL + h = H_b$, in which x = the quality of the steam, L = the latent heat of evaporation at supply pressure, and h = heat in the water at the same temperature. After reaching the calorimeter chamber the heat in the steam is what is due to its reduced pressure plus that due to its superheat, thus:—

$$H_c + 0{\cdot}48\,(T_1 - T_c),$$

in which H_c = the total heat in 1 lb. dry steam at calorimeter pressure, T_1 = the temperature indicated by calorimeter thermometer; T_c = the temperature of ordinary dry steam at the calorimeter pressure. As no heat is imported from an external source the total heat units in 1 lb. steam in the calorimeter cannot have increased, hence—

$$H_c + 0{\cdot}48\,(T_1 - T_c) = xL + h;$$

wherefore—

$$x = \{H_c - h + 0{\cdot}48\,(T_1 - T_c)\} \div L.$$

F. J. R.

541. *The Use of Zinc in Boilers.* **R. A. Douglass.** (Amer. Electn. 13. pp. 572–573, Dec., 1901.)—This is a practical paper directing attention to the limits to the usefulness of zinc in boilers, and giving some hints as to its application. The action being partly galvanic, the connections between zinc and boiler-plates should be carefully made. Cast-iron fittings in the neighbourhood of zinc sometimes become converted into a soft, almost spongy, condition, and therefore need extra care when in such a position. F. J. R.

542. *Heat-producing Power of Fuel.* **A. Adams.** (Soc. Chem. Ind., Journ. 20. pp. 972–974, Oct.; Discussion, pp. 1084–1085, Nov., 1901.)—The work of Dixon and others, in investigating the behaviour of the carbon gases, has caused attention to be directed to the question of the presence of moisture as affecting their formation. The present experiments show that in determinations of the calorific power of fuel by either Lewis Thompson's or William Thomson's calorimeter, errors have been hitherto neglected, which were due to moisture carried by the escaping gases and to incomplete combustion. By introducing to the fuel specimen a stream of oxygen saturated with moisture, both of these errors are greatly reduced if not wholly prevented. The results of three careful experiments, two with oxygen saturated with water vapour, and one with oxygen direct from a steel bottle, are given—the temperatures and radiation errors having been determined by a Geissler thermometer reading to $\frac{1}{200}$° C. These results were:—

	Moist Oxygen.		Dry Oxygen.
	I.	II.	III.
Corrected rise of temperature...	3·47° C.	3·4625° C.	3·36° C.
Mean value	3·466° C.		...
Cal. power in Cent. units.....	7205·4		6983·1

these give a difference of 220·3 units in favour of the moist oxygen. In addition to that there is a gain unaccounted for which is due to the latent heat of the water carried off by the gases. This amounts to 131·4 cals. or more than 1·9 per cent. in the above case. The explanation given is that with dry oxygen the combustion is not so perfect as with moisture present, in accordance with all recent investigations of the influence of moisture on chemical change. A list of papers by Dixon and Baker is given at the end of the paper, and the following figures, showing the magnitude of errors from various sources :—

An error of 1 mm. in the reading of the water-level causes an error of about 0·25–0·3 per cent. An error of about $\frac{1}{100}$° C. for 1 grm. of fuel burned, about 0·3 per cent. The effect of neglecting the radiation error varies greatly, but averages from 2–3 per cent. The error due to evaporation at 15° C. is 1 per cent., and that due to the formation of carbon monoxide is from 1-2 per cent.

Discussion.—In the discussion, **W. Thomson** said that he always used oxygen which had stood for twenty-four hours over water in a gas-holder, and he had not been able to find carbon monoxide in the gases in his determinations. **L. Archbutt** described the Mahler Bomb Calorimeter, giving an account of experiments with it on various English coals carried out by the late chemist of the L. & N. W. Railway—a table of these tests with comparative results from L. Thompson's calorimeter being also given. **A. Adams,** in reply, pointed out that although a gas-holder was included in W. Thomson's original apparatus, the influence of moisture was not suspected, and more often the gas-holder was discarded. The Berthelot-Mahler Calorimeter should be compared with results from W. Thomson's as L. Thompson's form was not reliable and results were not uniform. F. J. R.

543. *Powdered Coal.* (Eng. News, 46. pp. 415–416, Nov. 28, 1901.)—In America several systems of apparatus for pulverising coal, and for burning the powdered fuel have been developed, two of the most recent being described in this article, with illustrations of the apparatus. These are the "Cyclone Pulveriser," which is also shown adapted to a 2-Lancashire boiler plant, and the "Aero-Pulveriser," the application of which is shown to seven rotary kilns or furnaces for cement-making at the works of the Michigan Portland Cement Company. Both machines pulverise the coal by impact and attrition at a high velocity against metal surfaces, the lighter of the ground particles being continuously removed by means of a fan which exhausts from the pulveriser and delivers to the burning apparatus. The degree of fineness to which the fuel is ground, and the rate at which the coal dust is fed to the furnaces, are under control by regulating the speed of the fan. [See also Abstract No. 2232 (1901).] F. J. R.

544. *Tests of Mechanical Stokers.* **W. R. Roney.** (Elect. World and Engineer, 38. pp. 1079–1080, Dec. 28, 1901.)—The report of comparative tests of "American" and "Roney" stokers [see Abstract No. 153 (1902)] omitted some considerations essential to a just comparison. The evaporative performance of the boiler is not necessarily a standard of stoker efficiency unless both boilers be of the same type with heating surfaces and settings in the same condition. The author points out that the Babcock-Wilcox boiler and Roney stoker has been in use for over two and a half years, and were not in a good condition when tested, whereas the Stirling boiler and American stoker were quite new. If the results obtained from the Babcock-Wilcox boiler and

stoker when new and clean be taken, the cost of coal required per h.p. per hour would be \$34·08 instead of \$35·76; the cost per h.p. per year would be \$36·40 instead of \$38·06, and the cost of repairs would also be less, as diminished draught caused the higher repair costs in the table of costs. The function of a stoker is to burn coal—not to evaporate water—and the measure of its efficiency is the completeness of combustion as shown by analysis of the flue gases. These gases from the Roney stoker showed $CO_2 = 14·2$ per cent., $O = 4·67$ per cent, and $CO = 0·29$ per cent., and as the former evaporation from the boiler to which it was attached was 11·7 lbs., instead of 11·169, in the comparative tests, the Roney stoker was unfairly handicapped in these tests. F. J. R.

545. *Coal Conveyors at Edinburgh Electricity Works.* (Electrician, 48. pp. 291–292, Dec. 13, 1901.)—The coal-conveying plant here described is installed in the McDonald Road Works, Edinburgh, and was erected by the New Conveyor Company, of Smethwick. Small coal is shovelled from railway trucks into a concrete pit, 136 feet long, 14 feet wide, and 10 feet deep. It is then fed automatically into elevators, which have their boots sunk 7 ft. 6 in. below the bottom of the pit. The elevators have 16-inch buckets, attached at 2-feet pitch to the lifting chains, the whole being enclosed in cases inclined at an angle of 60° to the horizontal, the said cases being of ironwork, 66 feet long, and 3 feet by 2 feet in section. Each elevator raises 30 tons an hour, and they deliver together into one hopper. Thence the coal is taken by two 18-inch cross-conveyors across the boiler-house, which contains two rows of boilers, facing each other. It is then delivered through shoots into the middle of either of two longitudinal conveyors, each 12 inches wide by 130 feet long, which run respectively over the fronts of the two rows of boilers, the cross-conveyors being 17 ft. 6 in., and the longitudinal ones 9 ft. 6 in. above the level of the floor of the coal store. The longitudinal conveyors deposit the coal along the overhead stores in sunk steel hoppers, which connect by means of measuring chambers and guide shoots with the stoker hoppers. The coal store is 20 feet above the firing floor level, and contains twenty steel hoppers (one corresponding to each boiler), 11 ft. by 4 ft., by 4 ft. 6 in. deep. The whole is worked by enclosed motors, nine in number, each of 6¾ h.p. The article contains three drawings, which show the plan, cross-section and longitudinal section of the arrangement. The ashes are also automatically removed by other conveyors, which are further fully described. [The Electricity Works are described in Abstract No. 761 (1900).] W. H. S.

546. *Brick Chimneys for Power Stations.* **W. D. Ennis.** (Amer. Electn. 13. pp. 570–572, Dec., 1901.)—The proportions of a chimney are determined with reference to the quality of fuel and amount to be burned per hour, type and dimensions of furnace, boiler and setting, arrangement and size of flues, average and extreme limits of temperature of the external air, elevation above sea-level, variation of atmospheric humidity, and limiting dimensions of the chimney itself. The basis on which evaporation is calculated is that of taking a boiler-h.p. as equivalent to 34½ lbs. water evaporated per hour at 212° Fahr., and atmospheric pressure, and assuming that 6·9 lbs. of water are evaporated per lb. of coal. The consumption of steam in lbs. per i.h.p. per hour may be assumed at: 17½ lbs. for compound condensing engines; 23½ lbs. for simple condensing engines; 30 lbs. for simple non-condensing engines; 40 to 70 lbs. for uneconomical throttling or slide-valve engines, and

)0 lbs. for direct-acting simple steam pumps. For a central power station of verage size a good brick chimney will cost complete, in the neighbourhood f New York, about $15 per 1,000 bricks. The number of bricks per h.p. aries with the economy of the design. One chimney built for 8,000 boiler-p., 10 feet diameter, 225 high, with independent inner core, contained 00,000 bricks above the ground line. Another, 5 ft. 6 in. inside diameter, 25 feet high, contained 230,000 bricks. One built for 3,000 boiler-h.p. ontained 450,000 bricks. Another (without inner core) of octagonal shape, ith a round shaft, 10 feet in diameter and 125 feet high, had 165,000 bricks. ll these are exclusive of concrete foundations. The function of an inner ore is to increase the efficiency of the draught by retarding radiation through e chimney walls. This object is secured by the use of hollow bricks which re coming into use. The questions of cost of foundations, thickness of walls, e direction and junction of flues, and the ornamentation of chimneys are lso dealt with in this paper. F. J. R.

AUTOMOBILISM.[1]

547. *Locomobile Steam Motor Car.* (Engineer, 92. pp. 622-623, Dec. 20, 901.)—This car is described, and its working commented on. Great simpli-ity of mechanism is one of its leading features. Steam is raised in a vertical re-tube boiler located beneath the seats of the carriage body. The boiler is ired by a gasoline furnace, the spirit being supplied under pressure from a eservoir in connection with which is an air tank in which pressure is raised nd maintained by a hand air-pump. Steam is supplied to a simple two-ylinder vertical engine located in front of the boiler. Power is transmitted rom the crank-shaft to the live rear axle by means of a simple chain drive. The boiler is about 14 inches diameter × 14 inches high ; it has a solid drawn copper shell with steel end plates $\frac{1}{4}$ inch thick riveted on with $\frac{3}{8}$-inch rivets. The shell is overwound with two layers of steel piano wire. The boiler is raversed from end to end by 300 $\frac{1}{2}$-inch copper tubes. The total heating urface is about 42 square feet. One of these boilers tested to destruction ore a pressure of 1,200 lbs. per square inch. The blow-off pressure for normal working is 200 lbs. per square inch. Under the boiler is a flat vessel of sheet steel about $1\frac{1}{2}$ inches deep and traversed by numerous vertical air-ubes about $\frac{1}{2}$ inch bore. In the upper plate of this vessel round the tops of he air-tubes are drilled about 3,000 holes of $\frac{1}{30}$ square inch diameter. The gasoline under a pressure of about 35 lbs. per square inch traverses two of the oiler-tubes, where it is vaporised, and is then injected through a fine nozzle nto the furnace pan, and passing out of the holes round the air-tubes the vapour burns with a hot, smokeless flame. An automatic regulator operated by the steam pressure cuts down the petrol vapour supply as the pressure approaches 200 lbs. per square inch. The engine is of very simple construc-tion, the cylinders are $2\frac{1}{4}$-inch bore × 4 inch stroke, and the speed may be varied from about 11 to 600 r.p.m. At 300 r.p.m., and with an m.e.p. of 100 lbs. per square inch, about 2·4 b.h.p. is developed per cylinder. The chain drive gears down in the ratio of about 2·5 to 1, and the road wheels are 28 inches diameter, so that at 250 r.p.m. of the engine the car travels at about 8 miles per hour. The car weighs about 700 lbs. in running order and carries two persons. C. R. D'E.

[1] Electric Automobiles are described in the Section dealing with Electric Traction.

548. 100-*Mile Car Test.* (Horseless Age, 8. pp. 77–82, 1901.)—The following are the results of an independent trial. The highest award was obtained by the "Gasmobile" and "Haynes-Apperson" cars.

LONG ISLAND AUTOMOBILE HILL-CLIMBING AND ENDURANCE TEST, APRIL 20, 1901.

Make of Vehicle.	Horse-Power of Motor.	No. of Passengers.	Corrected Time. 100 Miles.	No. of Stops.	Total time of Stops. Min. Sec.	Per cent. of Efficiency.	Time. Min. Sec.	
De Dion-Bouton.....	5	2	6:58	1	9	98·2	1·48	Winner in class below 1,000 lbs.
De Dion-Bouton.....	5	2	—	—	—	—	3·34	Did not finish course.
De Dion-Bouton.....	5	2	—	—	—	—	—	Did not reach hill.
Darracq	6	2	7:05:30	5	9:30	98·1	3·30	—
De Dion-Bouton.....	5	2	—	—	—	—	1·40	Did not finish course.
"Packard"	9	2	7:58:30	4	41:30	91·7	5·50	—
"Gasmobile"	9	2	6:56	None.	None.	100	3·35	—
"Gasmobile"	9	2	—	—	—	—	2·35	Did not finish course.
Daimler (Delivery)	6	4	10:40	4	18	96·4	—	Exact time not taken at top of hill.
De Dion-Bouton.....	10	2	—	—	—	—	20·25	Did not finish course.
Electric Vehicle Co. ...	5	3	7:26	11	12	97·6	3·05	Winner in class between 1,000 and 2,000 lbs.
"Gasmobile"	9	2	5:34	3	20	96	11·25	Disqualified.
"Gasmobile"	9	2	5:53	1	0:15	99·9	2·39	Disqualified.
Haynes-Apperson	8	4	7:11	None.	None.	100	4·30	—
"Holyoke"	9	2	6:41	1	1	99·8	2·10	Winner in class above 2,000 lbs.

M. O'G.

549. *Alcohol Motor Car Trials in France.* (Engineer, 92. pp. 475–476, Nov. 8th, 1901.)—Some particulars are given relating to the trials carried out by the Minister of Agriculture [see Abstract No. 378 (1902)]. The road trials lasted three days, 100 kiloms. being travelled each day, starting from Paris. The following are some of the figures from the second day's run of 100 kiloms. Two Bardon carriages weighing 1,500 kilos and 1,200 kilos, engines 8 h.p. and 6 h.p., consumption 18·194 litres and 12·267 litres of pure alcohol respectively. During 15 kiloms. of level road a 10-h.p. Mors weighing 1,272 kilos consumed 3·78 litres and covered the distance in 18 min. The smaller Bardon took 31 min. for the same distance, and consumed 2·16 litres. A Gillet-Forest of 7 h.p. weighing 800 kilos consumed 8·24 litres of 50 per cent. alcohol for the 100 kiloms. A 7·5-h.p. Delahaye weighing 1,220 kilos consumed 10·27 litres of 50 per cent. A "Société Nancienne" of 10 h.p. weighing 1,240 kilos consumed 11·785 litres of 50 per cent. In the Industrial Vehicle class a Gillet-Forest lorry weighing 940 kilos and carrying 742 kilos covered the 100 kiloms. in 4h. 8m., and consumed 12·922 litres of 50 per cent. alcohol. A Panhard-Levassor lorry weighing 1,020 kilos and carrying 913 kilos took 4h. 30m., and consumed 11 litres of 50 per cent. Particulars relating to the Pengert Postal Van, and the Gobron Brillié, de Dietrich, and Bardon lorries are also given. It appears probable that the 50 per cent. alcohol will alone be able to compete with petrol on the score of cost. Photographs of four of the lorries are given. [See also Abstract No. 158 (1902).] C. R. D'E.

550. *Tyres.* **F. W. Barker.** (Horseless Age, 8. p. 100; and pp. 124–125, 1901. Abstract of a paper read before the Automobile Club of America.)—With pneumatic tyres, too narrow a tread cuts into a soft road-bed and too wide a tread wastes power. With the narrow tread flattening always occurs, with loss of stability of tread. No tyre possessing the quality of perfect stability is on the market. Electric welding is found to be the most expeditious and satisfactory method for fastening the tyres to the rim wheels.

M. O'G.

REFERENCES.

551. *Air Navigation.* **J. Armengaud, Jr.** (Comptes Rendus, 133. pp. 996–999, Dec. 9, 1901.)—In this paper a map is given showing the trajectory on the earth of the course of Santos-Dumont's ærostat in the experiment of October 19, 1901.

E. H. C.-H.

552. *Steam Engineering.* **P. Dawson.** (Eng. Mag. 22. pp. 161–176, Nov.; 333–335, Dec., 1901; pp. 519–537, Jan., and pp. 703–720, Feb., 1902.)—This series of articles, with numerous half-tone illustrations, consists mainly of descriptions of the steam plant in a number of British, Continental, and American Electric Power Stations, with a discussion of the principal respective characteristics of their present steam practice. G. W. DE T.

553. *Shaft Governors.* **H. F. Schmidt.** (Amer. Electn. 13. pp. 545–548, Nov., 1901.)—This paper contains diagrams and descriptions of some twenty forms of shaft governor used in modern American practice. H. R. C.

554. *Motor Lorries for Military Purposes.* (Engineer, 92. p. 601, Dec. 13, 1901.)—A general account is given of the results of the road trials at Aldershot, together with some particulars of the five competing vehicles. C. R. D'E.

GENERAL ELECTRICAL ENGINEERING.

555. *Dielectric Strength of Insulators.* **M. O'Gorman.** (Electrician, 47. pp. 845–846, Sept. 20, 1901.)—The author agrees with Dr. Baur [see Abstract No. 2467 (1901)] that the puncture resistance of an insulator expressed in terms of volts per centimetre at which it breaks down increases when the gap between the electrodes is small, but objects that the evidence is insufficient for Baur's general formula, and points out that the details of his experiment have not been given. Reference is made to Trowbridge's experiment, Maxwell's Electricity and Magnetism, 3rd edition, 1892, art. 51, p. 54, and Kelvin Electrostatics and Magnetism, 84. art. 340, p. 262, second edition. M. O'G.

556. *Losses of Energy in Accumulators.* **B. Hopkinson.** (Electrician, 48. pp. 211–214, Nov. 29 ; and pp. 263–264, Dec. 6, 1901.)—This paper describes and discusses a number of experiments on the efficiency of accumulators expressed in terms of the ratio of the energy given out to that put back again, not, as is usual, during a complete discharge and recharge, but during short cycles of time ranging from 20 seconds to 30 minutes, the object being to examine efficiency under conditions of working such as are experienced by regulator traction batteries. Two Tudor and one Chloride cell, each capable of giving an output of 7 amperes for nearly one hour were employed. Before each set of experiments the fully charged cells were discharged at a low current for a couple of hours, in order to prevent any evolution of gas during the tests ; then, after a rest on open circuit, they were put through a number of similar cycles of discharge and recharge until uniform results were obtained time after time, and from these the curves given in the paper were prepared. A cycle is twice the time of discharge or recharge, which were equal. For one-minute cycles at a current corresponding to about a one-hour discharge rate—conditions approximating to the average treatment of a "floating" battery—the efficiency was slightly over 90 per cent. One-minute cycles at about a six-hour discharge rate—representing a traction battery working on light load—the efficiency reached the very high figures of 96·5 per cent. and 97 per cent. Generally speaking, the shorter the cycle the higher the efficiency. For instance, in one set of experiments the loss of energy in one ten-minute cycle was 35 per cent. to 40 per cent. greater than in ten one-minute cycles, although practically the same energy was put into the cell in each case. The author finds that the more rapid the cycles the more nearly may the whole loss of energy be ascribed to the measured internal resistance of the cell, but that the calculated resistance of the layers of electrolyte between the plates only accounts for a small fraction of the total resistance. For longer cycles losses of energy in another direction besides internal resistance become relatively of more importance. This he has termed "electrolytic dissipation," and believes it to arise from local variations in the strength of the electrolyte and the generation of heat during the subsequent restoration of equilibrium by diffusion. E. J. W.

557. *Accumulator Acid.* **A. Pfaff.** (Centralblatt Accumulatoren, 2. pp. 73–78, and pp. 173–176, 1901.)—The writer has compiled a table showing the different strengths of acid used in the cells of fifteen makers. The

density of the acid varies from 1·142 to 1·120 ; the latter number corresponds to 29·84 per cent. H_2SO_4. A curve is given showing that the maximum conductivity of sulphuric acid is for 31 per cent. Calculations are made of the necessary variations of the density of the acid during charging and discharging from the assumed chemical reactions in the cell. These values are compared with those actually obtained. The experimental results are exhibited in the forms of curves showing the number of grammes of acid used per ampère-hour at various current densities and similar relations. The author has more particularly studied portable cells, each with two positive and three negative plates, which were charged with sulphuric acid with densities varying from 10 to 30 Béaume. Curves are plotted of the behaviour during charge and discharge of these cells. The following table shows generally the result in four cases :—

Acid density before charging $= a$	24·5	22	17	13
„ „ discharging $= b$...	30	28	22	19
Mean acid density $= \frac{a+b}{2}$	27·5	25	19·5	16
Charging time in hours	7h. 15′	6h. 20′	4h. 40′	4h. 12′
Discharging „	6h. 40′	5h. 50′	4h. 20′	3h. 55′
Capacity in ampere-hours	33·3	29·25	21·7	19·8
Mean voltage during charge	2·281	2·264	2·217	2·196
„ „ discharge	1·976	1·964	1·927	1·908
Efficiency in ampere-hours.....	91·95%	92·10%	92·86%	93·26%
„ watt-hours	79·66%	79·9%	80·7%	81·02%

W. W. H. G.

558. *Tests of some Primary Batteries.* **F. Peters.** (Centralblatt Accumulatoren, 2. pp. 121–122 ; 133–135 ; and pp. 269–270, 1901.)—Tests have been made of two forms of low-resistance primary cells of the Leclanché type called the Reform and the Hydra cells ; also of the dry cell of the Columbus Electricitats Gesellschaft, and the results are given here. The last article gives the results of tests on the use of ammonium persulphate as a depolariser. It was found to greatly increase the depolarising power and life of the cell, provided that the current taken was not too large, and that the periods of rest were longer than those of work. J. B. H.

559. *Iron-clad Horn Lightning Arrester.* **E. Klein.** (Elektrotechn. Zeitschr. 22. pp. 1045–1046, Dec. 19, 1901.)—By backing the horns with iron the magnetic field produced assists the hot air in driving the arc upwards. Under conditions in which, without iron backing, the arc remained across the narrow gap, with backing it was immediately driven upwards and extinguished. It was effective also in driving the arc downwards, when the arrester was inverted, against the action of the hot air. The negative end of the arc rises more quickly than the positive. G. H. B.

560. *Electrical Operation of Machinery.* **R. T. Lozier.** (Elect. Rev. N.Y. 39. pp. 754–758, Dec. 21, 1901. Paper read before the New York Electrical Society, Nov. 26, 1901.)—A review is given of previous papers on the subject, with examples of the most recent practice. In large establishments it is found that, with individual motor driving, the average load on the generating plant is but $\frac{1}{6}$, or $16\frac{2}{3}$ per cent. of the total connected load.

The ratio of cost of power to the product of the shop is given. With the

cost of steam power at £7 10s. per h.p. per year, the average ratios are said to be 2 per cent. of product for complete belting transmission, 1 per cent. for subdivided motor transmission, and 0·4 per cent. for individual motor transmission. With triple expansion engines the cost per h.p. year is put at £5, and the corresponding percentages are $1\frac{3}{4}$ per cent., 0·8 per cent., 0·4 per cent. Under the very best conditions, therefore, the subdivided motor system would effect a saving in a works producing annually to the value of £207,000, sufficient to pay 10 per cent. per annum on a plant costing £17,500, and the individual motor method would support at the same rate a plant costing £27,000. Owing to the increased speed control with the individual motor system, the output of a works can be increased from 8 per cent. to 25 per cent. with the same equipment and pay roll. An instance is given of a printing works in which the output was increased 80 per cent. Assuming only a 10 per cent. increase, this means, on the same basis as before, an increase of £20,700. Allowing £5,175 for raw material, the motor equipment is credited with £15,525, which will probably more than pay for the entire equipment of individual motors in the first year, besides the saving in power transmission. Several illustrations of motor-driven machines are given. [See also Abstract No. 321 (1900).] F. B.

561. *135-Ton Electric Crane.* (Engineer, 92. p. 454, Nov. 1, and pp. 561–562, Nov. 29, 1901.)—This crane, which is worked by four motors, was constructed by Vaughan, of Manchester, for Armstrong, Whitworth & Co. Three of the motors are secured to the outer side of the crab, and run at 300 r.p.m. Each is controlled by a resistance of the liquid type, placed in the operator's cage. The girders are of double-web section, being 54 feet in length, 4 feet deep at their terminations, and 6 feet deep at their centres. The top and bottom booms consist of two steel plates, each 1 ft. 7 in. wide by $\frac{7}{8}$ inch thick, the web plates being $\frac{5}{16}$ inch thick. The fourth motor is carried at one end of the crane, for operating the longitudinal travel, which is at the rate of 200 feet per minute. The travelling speed of the crab is 100 feet per minute. For the main hoist two barrels are provided, rotating in opposite directions; the reduction of speed is effected first by worm and worm-wheel, and then by spur-wheels and pinion. The usual electromagnetic brake, which raises and lowers the brake levers, is provided. Two rates of hoisting are allowed for, the change wheels and clutch gear being operated from the platforms. There is also an auxiliary barrel for dealing rapidly with loads up to 10 tons. Three drawings are given, showing the general construction.

W. H. S.

REFERENCES.

562. *Motor-starting and Reversing Switch.* **R. Krause.** (Elektrotechn. Zeitschr. 22. pp. 1066–1067, Dec. 26, 1901.)—An illustrated description of an automatic motor-starting and reversing switch, fitted with no-voltage and overload electromagnets. A. H.

563. *Electrical Appliances in Ship-building Yards.* **S. F. Walker.** (Eng. Mag. 22. pp. 679–692, Feb., and pp. 854–870, March, 1902.)—The various appliances illustrated and described include electrically driven bending rolls, a cold saw, cranes and winches, pumps, and general machine tools both fixed and portable.

G. W. DE T.

GENERATORS, MOTORS, AND TRANSFORMERS.

564. *Standardising Electrical Machinery.* **J. T. Broderick.** (Eng. Mag. 22. pp. 24–30, Oct.; and pp. 177–184, Nov., 1901.)—The author considers generally the effect of standardising electrical machinery on the questions of cost, delivery, and quality. The voltages and frequencies standardised by the American Institution of Electrical Engineers are given by the author as follows: For continuous-current low-pressure generators, terminal voltages 125, 250, and 550; for continuous-current and alternating low-pressure circuits, terminal voltages 110 and 220; for continuous-current power circuits for railway and other service, voltage 500; for alternating-current high-pressure circuits, voltages at the receiving end, 1,000, 2,000, 3,000, 6,000, 10,000 15,000, and 20,000; for alternating current high-pressure generators, or generating systems, terminal voltages, 1,150, 2,300, and 3,450. A maximum drop in transmission of 15 per cent. of the pressures at the receiving end is allowed in the voltages specified for high-pressure alternating currents. For alternating-current circuits, frequencies 25, 30, 40, 60, and 120. G. W. DE T.

565. *Effect of Dimensions of Teeth on Output of Dynamos.* **M. Corsepius.** (Elektrotechn. Zeitschr. 22. pp. 988–991, Nov. 28; 1003–1006, Dec. 5; and pp. 1023–1026, Dec. 12, 1901.)—In this paper the author considers in detail the effect of varying the size and shape of the teeth on the output of the armature, taking into consideration the permissible limits as regards sparking and heating. The teeth being strongly magnetised, the author assumes that the law B = constant + H may be used in investigating the distribution of induction along a tooth. The diameter d (in cms.) of the armature is given by the formula—

$$d^3 = \frac{10^8 . \mathrm{E}.g.p.0{\cdot}675}{\zeta\,(1-\zeta).\mathrm{C.D.B}.n.m'}$$

where E = e.m.f., in volts; g = diameter of covered wire used in winding armature in millimetres; p = number of poles; ζ = ratio of width of tooth to pitch of teeth; C = ratio of length to diameter of armature; D = ratio of pole-arc to pole-pitch; B = apparent induction in teeth; n = revs. per min.; m = number of wires per slot. The greater part of the paper deals with the effect of altering ζ on the performance of the machine as regards sparking and heating. In connection with the former, the author states that the armature cross-turns should not exceed from $\frac{1}{4}$ to $\frac{1}{3}$ of the ampere-turns required for maintaining the flux across the (double) air-gap and in the teeth. A. H.

566. *Voltage-Drop in Alternators.* **J. Fischer-Hinnen.** (Elektrotechn. Zeitschr. 22. pp. 1061–1065, Dec. 26, 1901.)—The two methods commonly in use for predetermining the regulation of an alternator from its open-circuit and short-circuit characteristics are those due to Behn-Eschenburg and Rothert. In Behn-Eschenburg's method, the equivalent inductance of the alternator armature is found from the short-circuit curve, and the drop due to it is compounded vectorially with the p.d. to give the e.m.f. In Rothert's

method [see Abstract No. 591 (1900)] we have the composition of ampere-turns instead of e.m.f.'s. The author gives a table containing the experimentally determined values of the p.d. and the calculated ones for fifteen different machines, and from this table it appears that in general the values calculated by Behn-Eschenburg's method are too low, while those obtained by Rothert's method are too high. A much better agreement is obtained by using a recent method due to Potier, which may be regarded as a combination of the above two methods. Potier compounds the field and armature ampere-turns, thus finding the resultant ampere-turns. But instead of taking—as is done in Rothert's method—the value of the e.m.f. corresponding to the resultant ampere-turns (and obtained from the open-circuit curve) to represent the p.d., he further subtracts from this e.m.f. (vectorially) the inductance drop in the armature, thus getting the p.d. The method is somewhat tedious, and tables are given by the author to facilitate the necessary calculations. A. H.

567. *Compounding of Alternators.* **A. Heyland.** (Elektrotechn. Zeitschr. 22. pp. 1021–1023, Dec. 12, 1901.)—As applied to an alternator of ordinary construction, this method consists in providing the rotating field magnet with an additional winding resembling Leblanc's *amortisseur*, but connected to a commutator, by means of which it may be supplied with the main alternating current. The arrangement is diagrammatically shown in Fig. 1, in which the shuttle-shaped portion represents a 2-pole field magnet. By suitably adjusting the position of the brushes, the magnetic effects due to leakage and armature reaction may be balanced by the magnetic effect due to the com-

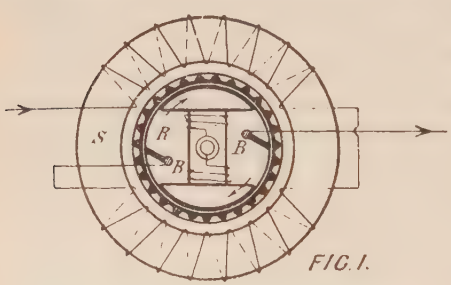


FIG. 1.

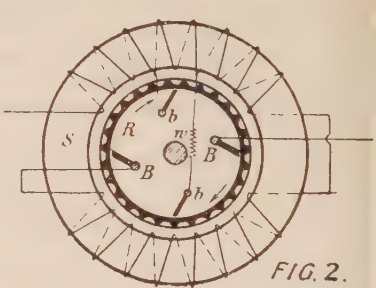


FIG. 2.

pound winding, which may also provide a sufficiently large field to compensate for the resistance drop. Instead of full, partial compounding may be used. The compounding of alternators may be adopted with advantage in the case of single machines; where machines are run in parallel compounding is excluded, since its adoption would annul those controlling currents on which satisfactory parallel running depends. But one or two machines might be compounded, and would then supply the wattless component of the current. [In the case of two machines, the current of the first machine would supply the compound winding of the second, and *vice versâ*—an arrangement similar to that used in continuous-current generators.] The author next considers the application of his method of compounding to an asynchronous generator of the type recently described by him [see Abstract No. 2475 (1901)]. In this case, all that is necessary is to provide another set of brushes, through which the main current may be introduced into the rotor winding. The arrangement in its simplest form is shown in Fig. 2, in which *bb* are the brushes supplying the exciting current, and BB those supplying the compounding current. A. H.

568. *Measurement of Coefficients of Speed Variation of Alternators.* **J. Blondin.** (Écl. Électr. 29. pp. 252–258, Nov. 16, 1901.)—Owing to the variation of engine effort during the stroke and the obliquity of the connecting rod, the flywheel of an engine varies in speed in one revolution between Ω maximum and Ω minimum ; the *coefficient of variation* during one revolution is defined as—

$$k = \frac{\Omega \text{ max.} - \Omega \text{ min.}}{2\,\Omega \text{ mean}}$$

There is also another variation of longer period due to the elasticity of materials and to want of balance in any rotating parts whose angular speed is a submultiple of that of the main shaft. Admitting the periodicity of this latter variation, a new coefficient, that of variation during n revolutions, is required; and this is defined similarly as—

$$k' = \frac{\Omega' \text{ max.} - \Omega' \text{ min.}}{2\Omega' \text{ mean.}}$$

Ω' being, with the respective suffixes, the maximum, minimum, and mean angular speeds during n revolutions.

If an ideal crank moving uniformly makes one whole turn in the same time that a real crank makes a whole turn with a varying speed, the two cranks will form at every instant an angle varying between zero and a maximum value θ. This angle θ is defined as the *angle of maximum displacement* during one revolution. θ' is the maximum displacement during n turns. The angle of maximum displacement is, generally speaking, a complicated function of the coefficient of variation, and it is not possible to evaluate the one quantity from a knowledge of the other. If, however, the actual speed is known at any instant, an integration will give the maximum displacement. The determination of this latter quantity, therefore, reduces to a measure of the instantaneous speed of rotation.

Such measurements may be classified as (1) mechanical, (2) acoustic, (3) electrical, and (4) optical. *Mechanical methods* compare the actual instantaneous speed of a revolving part with that of another body moving either (*a*) periodically or (*b*) with a uniform movement of rotation. Two arrangements are described under heading (*a*) in which a tuning-fork to which a uniform longitudinal motion is given traces a sinuous curve on a piece of smoked paper wrapped on a revolving cylinder rigidly coupled to the shaft of which the variations of speed are to be measured. The varying distance between the peaks of the waves is a measure at any instant of the actual velocity of the cylinder. This method demands great nicety of measurement of the order of 1/100th of a mm. The other mechanical method compares the variable motion with that of a disc or flywheel with a very large moment of inertia, connected with the shaft of variable motion by friction gear or an elastic coupling. This method is not nearly so exact as the former, and besides this the speed of the disc is that of the mean velocity of the shaft during a number of turns, and does not give the quantities k and θ corresponding to one revolution. (2) *Acoustic methods.*—The principle of these is to produce a note of which the pitch corresponds to the instantaneous speed of the shaft, *e.g.*, by means of a toothed wheel and card. This method lacks sensitiveness. (3) *Electrical methods.*—One way is to measure the instantaneous e.m.f. of a small direct-current dynamo mounted on the shaft of the machine. The current from the dynamo passes through a differential galvanometer, of which one winding is fed by a steady current from an independent source. The

latter is adjusted so that at the mean speed the galvanometer gives no deflection; a movement of the needle in one direction or the other indicates a corresponding increase or decrease of speed in the shaft. The objections to this method are (1) that the speed variations detected are not those occurring in one revolution, but relate to the mean speed of several revolutions; (2) errors are introduced by commutation and want of symmetry in the windings; (3) self-induction produces exactly the same effect as the elastic coupling in the mechanical methods, and involves the same lack of sensitiveness. In this connection an ingenious method, due to Claude, is described for magnifying the angular displacements to be observed. A bicycle wheel is applied against the rim of the flywheel; by reason of the perfect adherence of the rubber tyre, and the small inertia of the wheel, the fluctuations in movement of the flywheel are faithfully reproduced, and the angular displacement magnified in proportion to the diameters of the two wheels. On the axis of the bicycle wheel are fixed the field magnets of a small motor, with brushes attached. A current is passed through the armature such as to turn the latter in the opposite direction to that in which the bicycle wheel rotates, and at an equal speed. The armature is then motionless in space. An index attached to the shaft will then show by its movement in one direction or the other any increase or decrease in the speed of the bicycle wheel, and therefore of the flywheel from which its motion is derived. (4) *Optical methods.*—These do not involve any of the difficulties which are met with in the other methods. In the case of an alternator with rotating fields a fixed beam of light passing between the moving pole-pieces is examined through a slot in a revolving disc. If the movement of the alternator is perfectly regular and the speed of the disc is adjusted so that the slot is always in the same position when the beam of light is passing through the spaces between the field-poles, these will appear motionless; if the speed of the alternator varies between a maximum and minimum, the image on the retina will oscillate between two extreme positions, the angular displacement of which will be double the angle θ required. One or two modifications of this stroboscopic method, which is capable of great accuracy, are described. B. P. S.

569. *Street Railway Motors.* **G. T. Hanchett.** (Street Rly. Journ. 18. pp. 521–525, Dec., 1901.)—This paper deals with the principles upon which the selection of railway motors for given work should be based. Makers' ratings are an insufficient guide; reference must be made to actual performance curves over the limits of load. These are placed as follows, in order of importance; in all cases the load in amperes is plotted as abscissæ: (1) Horizontal effort, or draw-bar pull; (2) speed; (3) temperature; (4) horse-power input; (5) efficiency; (6) horse-power output. The author discusses each of these curves, of which typical examples are reproduced, briefly explaining the causes which determine the particular character of each, and showing how one curve can be checked against another, and inferences can thus be drawn as to whether manufacturers' curves show the results of actual tests or not. In the temperature curve, otherwise called the time curve, minutes are plotted against amperes, the ordinates showing the time taken under any given load for the motor to reach a limit of temperature, say 75° C. above that of the air. The latter part of the paper is given up to a discussion of the heating problem; and a method is indicated of determining the heat performance of motors with due regard to the complex conditions of actual working. The principle is to ascertain experimentally the thermal capacity C of the motor—that is, the number of units of heat, expressed in kilowatt-hours, which raise it

to a given temperature T, taken as the permissible heating limit; and R the rate of radiation at the same temperature, in watts, is also found experimetally. For a level run, by integration of a loss curve, plotted with reference to the current load, with time for abscissæ, the total heat delivered to the motor within the period 0 to L is found; thus $\frac{E}{L}$, the average rate of radiation during the run, can be found, which must of course not exceed R on an extended run. The problem is more extended on gradients, or where the load is for a considerable period much over the normal. Here the heat inertia or reserve capacity of the motor—*i.e.*, the difference between C and the heat contained in the motor at the beginning of the run—is depended upon to store up the heat generated, to be radiated at a more favourable time. The formula $\frac{2C(LR-E)}{R(2iL-LR-E)}$ is deduced as an expression for the permissible time that the motor will carry the load under the given conditions (i = the loss in watts). Suggestions are made as to the methods by which the thermal capacity C and rate of radiation R should be determined; and it is pointed out that C is not really a constant but a function of the current; for important calculations various values of C at different currents should be experimentally determined and embodied in a curve, and that value of C should be selected which corresponds to the r.m.s. of the currents about to be applied to the motor.

B. P. S.

570. *Testing Induction Motors.* **A. S. M'Allister.** (Elect. World and Engineer, 39. pp. 78–80, Jan. 11, 1902.)—Simple methods are shown for determining the slip, stator and rotor losses, &c., of polyphase induction motors. The percentage of slip is equal to the ratio of copper losses in the rotor to the total power impressed on it. By measuring the current in the rotor and its resistance the slip may be determined. In the case of a squirrel-cage rotor the resistance is measured indirectly by clamping the rotor, supplying current as to a short-circuited transformer, measuring the total power supplied and deducting the C^2R losses in the stator. *Torque.*—This is shown to be equal to the rotor input divided by the speed of synchronism. Measuring the power supplied to the motor, deducting the stator losses, and dividing by the synchronous speed, gives the total torque. On further deducting frictional losses the effective torque is obtained. *Power-factor.*—In a two-phase motor the wattmeter measurements on the two phases are $CE\cos\phi$ and $CE\sin\phi$ respectively. The ratio of these readings gives $\tan\phi$. In a three-phase motor readings on two phases give $W_1 = CE\cos(\phi - 30)$ and $W_2 = CE\cos(\phi + 30)$ respectively, whence $\tan\phi = \sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2}$. Curves and tables are given showing the results obtained by these methods. [See also Abstract No. 83 (1902).]

A. E. L.

571. *Induction Motor used as Synchronous Motor.* **E. Danielson.** (Elektrotechn. Zeitschr. 22. pp. 1065–1066, Dec. 26, 1901.)—An over-excited synchronous motor may, as is well known, be used for improving the power-factor of an inductive load. The reason why such motors have not been more largely used is due to the difficulty of starting them, and to the fact that it is impossible to start under load. This difficulty may be overcome by using an ordinary induction motor with a star-connected three-phase rotor winding, and converting it into a synchronous motor by sending a steady current through one of the phases, the current returning through the remaining two

phases connected in parallel. The author describes the characteristics of such a motor, mentioning the results of some experimental tests. So long as the overload does not exceed 50 per cent., the motor will continue to run in synchronism. Beyond this point it gets out of step, but instead of stopping—as would be the case with an ordinary synchronous motor—it goes on running as an induction motor ; there being appreciable fluctuations in the speed and the (continuous) rotor current. In order once more to bring the motor up to synchronism the load has to be reduced to half its normal value. In starting such a motor it would be used as a simple induction motor, and when it has attained full speed the rotor would be polarised and pulled into synchronism. The author draws attention to the fact that since two of the phases of the rotor winding are short-circuited, they will act as damping coils and prevent hunting. A. H.

572. *Polyphase Motor with Three Speeds.* (Zeitschr. Elektrotechn., Wien, 19. pp. 637–641, Dec. 29, 1901.)—Motors built by C. Wüst & Co. of Seebach, near Zürich, have three stators arranged coaxially with a common squirrel-cage rotor. The three stators are wound with different numbers of poles so that different speeds may be obtained by supplying current to one or another. If two stators be supplied with current in parallel, the motor runs at approximately the speed corresponding to that with the greater number of poles. The output can thus be doubled, but at a great sacrifice of efficiency ; the losses due to the great slip of the rotor with reference to the second stator are so great that this load can only be kept on for a few minutes at a time. The arrangement may be employed for temporary overloads. All three stators may be switched in together to give triple output, but with even greater sacrifice of efficiency. Some curves are given, obtained from a 3·5-h.p. motor with 4-, 6-, and 8-pole stators, arranged to give this output continuously on a 50-cycle circuit, or two or three times this power for short periods. Its weight is 290 kg. A. E. L.

573. *A Simple Alternating-Current Motor.* **P. Boucherot.** (Ind. Élect. 10. pp. 541–542, Dec. 10, 1901.)—Hospitalier, in the simplest form of his "ondograph," uses a small synchronous alternating-current motor which requires no excitation with direct current. The rotor is simply a bundle of iron stampings, the length of which is about four times the breadth, and the stator is an alternating-current magnet. The author makes calculations to find the amount of power that can be obtained from such a motor. He regards the motor as a coil of variable self-inductance $L(\alpha - \cos 2\omega t)$, where α is a constant greater than unity. He then finds expressions for the power absorbed by it when fed at constant pressure and at constant current respectively. The theory is instructive, but of course the power-factor and the efficiency of this kind of motor are small, and, as the rotor has to be brought into synchronism by external means, it is only useful when very little power is required. A. R.

REFERENCE.

574. *Polyphase Machinery.* **A. C. Eborall.** (Soc. Arts, Journ. 49. pp. 749–757, Sept. 13 ; 761–768, Sept. 20 ; 773–782, Sept. 27 ; 785–792, Oct. 4 ; 797–808, Oct. 11 ; 809–818, Oct. 18 ; 821–831, Oct. 25, and pp. 833–844, Nov. 1, 1901.)—A series of lectures dealing with the question of the design of polyphase generators, transformers, and motors, containing much useful theoretical and practical information. W. H. S.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

575. *Locating Faults in Underground Cables.* **H. G. Stott.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 807–811, Nov., 1901.)—It is pointed out that with small conductors, such as those used for telegraph cables, the ordinary Blavier and loop tests suffice, but, since the percentage error in locating a fault varies directly with the cross-section of the cable, these methods cannot be depended on, and hence are of no practical value for lighting and power purposes. There remain three other methods, which may be called—(*a*) The cut-and-try method. (*b*) The smoke method. (*c*) The compass method. The first of these simply means cutting the cable into as many sections as necessary until the fault is finally located in a length between the manholes. This is a slow, expensive, and unscientific method, and should only be used as a last resort. The smoke method is also crude, consisting, as it does, of passing a current of sufficient strength through the cable into the fault so as to cause the insulation to burn and to give out volumes of smoke, by means of which the location of the burnt part may be discovered on opening up the manholes. The writer believes that the compass method is the only practical and safe procedure. A current of about ten amperes is sent through the cable into the earth; this current is reversed automatically every ten seconds. A manhole is then opened near the centre of the cable length, and a pocket compass laid on the faulty cable and observed for say half a minute. If the fault is further away from the source of the reversed current, the compass will have its direction periodically reversed. The test is repeated at a more distant manhole, say a mile further from the source of the reversed current, and so on until the fault is located between two manholes. The form of reverser used by the Manhattan Railway Company consists of a $\frac{1}{4}$-h.p. three-phase induction motor, geared to a two-part commutator, which revolves in oil in order to insure the quick reversal of current without danger of arcing across the segments. As a source of direct current, a continuous current arc-light machine, or a 500-volt supply with a resistance in circuit, may be used. Before putting on the reversed current it is advisable to break down the fault by the application of a high-pressure testing transformer for a few seconds. The method of testing is particularly useful in a network of cables because the test can be applied without shutting down, providing it is an alternating system and there is no permanent earth. The author has used the method for four years with most satisfactory results. W. W. H. G.

576. *Cables in a Solid System.* (Elect. Engin. 28. pp. 554–555, Oct. 18, 1901.)—Siemens and Company's solid system consists of troughs of hard salt-glazed stoneware in lengths of about two feet. The ends of the lengths form a spigot and socket joint, but the spigot piece forms a bridge which supports the cable in lieu of separate bridges of wood used in other systems. The troughs are covered with stoneware slabs. No cement or jointing material is used. The trough is presumably filled in with bitumen. Joints in the lead-covered cables are made, without soldering the lead, by making up the insulation with a non-hygroscopic tape which extends over both ends of the

lead casing. A lead tube, previously slipped over the cable, is drawn over the joint and merely bound down with wires on to the non-hygroscopic tape, which acts as an elastic packing. M. O'G.

577. *Long-Distance Transmission Lines.* **C. W. Startsman.** (Elect. Rev., N.Y. 39. pp. 781–786, Dec. 28, 1901.)—The paper deals with the general theory of the transmission of current-waves along a line of considerable length, the resistance, inductance, and capacity of the line being all taken into consideration. The problem is treated graphically and analytically, and is illustrated by a numerical example. A. H.

578. *Wiring Rules in Germany.* **F. Ross.** (Zeitschr. Elektrotechn., Wien, 19. pp. 593–595, Dec. 8, 1901.)—The author deals with some of the alterations which have been introduced by the new wiring rules lately sanctioned by the Verband Deutscher Elektrotechniker, and also points out certain differences which exist between the Austrian and German regulations. W. H. S.

579. *Electrical Distribution in Large Cities.* **L. A. Ferguson.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 791–805, Nov., 1901.)—This paper deals mainly with the electrical supply stations of Chicago, where the old method of a number of steam-generating stations scattered throughout the city is now generally given up, the smaller generating stations being converted into sub-stations, and the generation being centralised in one or two large power stations suitably located as regards water and coal supply. Several power stations exist in Europe and America arranged for an ultimate output of 50,000 to 100,000 h.p. In some cases the old power stations which these large stations supplant are retained as sub-generating stations and used during the heavy load in the winter months. Even with the relatively high cost of generation at such stations a saving is found to be effected on the alternative method of providing extra plant at the main station sufficient to cope with this load. Choice of site for main power-house is important; the author discusses the points to be considered in deciding the question. As regards the system to be adopted, he advocates direct current for the lighting and power work of the strictly business and city residential districts, and alternating for the more scattered residential and suburban portions. Analysis of the output of Chicago Central Station Companies (railways excluded) shows that 23·4 per cent. is by 60 periods distribution over an area of 58 square miles, and the remainder by direct-current distribution over 10 square miles. As regards the particular company in which the author is interested, as the present plant becomes obsolete it is being replaced by 25-cycle generators, with rotaries in substations to supply the districts of large demand, and motor generators delivering 60-cycle current in districts where electric development is less advanced. The distribution of continuous current by rotaries is in this station rapidly gaining ground on that produced by continuous-current generators, the latter being expected to show only a slight increase over last year's output, while the former is expected to increase by 300 per cent.; but it will take several years to make the complete change from generation by direct current to that by 25-cycle alternating current without sacrificing the value of present investment in plant of the former type.

As regards the supply of current for power, the output of two Chicago companies is nearly 31 per cent. for power (about two-fifths of this being for elevator work) as against 69 per cent. for lighting, taken over the whole year. The importance of the power business has led to the adoption of the three-

wire direct-current system in the business and city residential districts. As against alternating motors, the original cost of direct-current motors and their equipment is much less; the author considers the present selling price of three-phase motors in America to be excessive. For lift work also, alternating motors are not nearly so well adapted as direct-current motors. The ability to instal an economical and reliable lift equipment is often a determining factor in the choice between central station service and the installation of a private plant, and by its aid a decided saving over hydraulically worked lifts has often been shown by owners of large mercantile establishments, &c., who have adopted the former method. The growing necessity for charging equipments for automobiles is also adduced as an argument for direct-current distribution, and the advantages of storage batteries are dwelt upon from the points of view of pressure regulation, for discharging during the peak of the load, or for emergency or breakdown. A particular application is indicated of the storage battery, when it is located at the central distributing point of a system with feeders radiating to various points in the network, more or less distant from the centre; by the use of two or more end cell-switches which can be connected to one or more auxiliary busbars with a different number of cells in series, different potentials may be provided at the centre of distribution, and the pressures at the far ends of the various feeders can thus be equalised during times of heavy load. At the author's station the system of generation adopted was 25-cycle three-phase current, generated by double-current machines arranged for stepping up to 4,500 and 9,000 volts. The necessary three-phase current for the outlying rotary substations can thus be supplied very efficiently, the generators supplying at the same time direct current to the low-tension network. One of these double-current machines has a capacity of 2,500 kw., generating 300 volts direct current and 180 volts three-phase alternating. Additional plants will be 25-cycle three-phasers, generating directly 9,000 volts, the line pressure. The periodicity chosen was selected in preference to 60 cycles as being less expensive in first cost of plant, giving smaller loss in high voltage underground transmission, with less strain on the insulation in case of any disturbance of the system, and as being more suitable for operating rotaries. The paper concludes with a description of the general arrangement of the service in three districts of Chicago where 60-cycle transmission (formerly 125-cycle) is in use, accompanied by a map showing the positions of the main generating stations and substations, with the principal mains and feeders; and with a brief comparison of the systems employed in Berlin and Milan with that described by the author. B. P. S.

580. *Electrical Distribution in Cities of Moderate Size.* **W. L. Robb.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 843–848, Nov., 1901.)—The author explains that by "cities of moderate size" he means those having a population of 200,000 or less. Towns of less than 50,000 inhabitants form a class by themselves. In this smaller class, in which there is generally a considerable area to be lighted extending in all directions perhaps two or three miles from the central station, and in which there is usually no tendency to put in isolated plants, and little objection to overhead wires, the author would generate only three-phase alternating current at 60 periods and about 2,300 volts. The street arc lighting should be by constant-current series enclosed lamps, the distribution for lighting being generally single-phase; motors under 3-h.p. would also be best operated from the single-phase system. At points where there is any concentration of lighting and power a 220-volt

3-wire system of secondary wiring should be used, being supplied by one or more transformers placed at suitable points. In cities of the larger class (between 50,000 and 200,000 inhabitants), the area lighted is very large, and while commercial lighting and power is concentrated in sections, lighting and power service has to be supplied practically everywhere. In this class of cities there is a tendency to instal private plants, and underground distribution is imperative.

The conditions existing at present in the business section of such cities make it desirable that the supply here should be a direct current one, and the author prefers a 220-volt to a 440-volt 3-wire system, considering that the saving in copper, if the higher pressure is used, is more than counterbalanced by the inferiority of high-voltage lamps, either arc or incandescent. The direct current would be supplied from rotaries in substations, the primary generation being 3-phase, 60 period, 4-wire at a pressure of 2,300 volts. The pressure on the D.C. side would be varied by means of the static transformers used in connection with the rotaries, no boosters being required. The distribution boxes should preferably be of the lamp-post type, so as not to obstruct traffic. The distribution outside the business section should everywhere be on the alternating system. From the power-house the current should be taken, 3-phase 4-wire, to various distributing centres, whence the supply should be ordinarily by single-phase circuits, except where large motors are used, when additional phase-wires would be taken from the distributing centres. In congested areas the distribution should be by 220-volt 3-wire secondary mains fed by large transformers ; the neutral wire should be earthed. Street lighting should be by series constant-current arcs. To ensure a satisfactory alternating-current distribution of any size, it should be possible to supply current to the different feeders at different pressures, which can be done by boosting transformers or by Emmet's automatic device. B. P. S.

581. *Three-phase Distribution with Single-phase Circuits.* **W. L. R. Emmet.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 833–841, Nov., 1901.)—The author of this paper prefers a three-phase system to a single- or two-phase, for the reason, amongst others, that while for single-phase working it is better than two-phase, a three-phase generator is as good and cheap when used as a single-phase machine as if it had been designed specially for this purpose. It thus meets either of the other systems on equal terms in their own field, while keeping its own special advantages. For use on single-phase circuits a three-phase generator should have a Y-connected winding. Motors and rotaries tend to equalise the load between the phases, and thus increase the capacity of the system. The only part of a lighting company's load which cannot be advantageously divided between the phases is the low-pressure interconnected distributing system ; but there will generally be outlying circuits, which can be worked from other phases. Arc-lighting transformers, &c., can also be put upon the least-used phases, and help to balance the system. Practically the three-phase generator can be used at its rated capacity on any system. The variations of pressure between the phases, due to want of balance when single-phase circuits are being operated, are generally small, and can easily be controlled by regulators in feeder circuits. They may in some cases be actually a convenience, since they give a choice of pressure to suit any feeder. Two systems of low-tension distribution in connection with three-phase generators are discussed, viz., the single-phase, three-wire, and the three-phase, four-wire systems, diagrams being given of each. The former is favourably contrasted with direct-current

three-wire systems, and shown to give, with intelligent handling, practically perfect regulation. The three-phase, four-wire method is probably the most desirable when it can be consistently used on a large scale, but should only be employed where a good balance of the phases can be ensured. The copper economy is slightly in favour of this system as against the other, and it has the advantage that its outside wires are available for operating motors. When the single-phase, three-wire system is used, a fourth wire must be specially run for this purpose. After stating some simple rules to be kept in view when arranging distributing systems, the author describes the method of primary distribution which consists in connecting the Y-winding of the generator to four feeders—three outsides and a neutral. The pressure between each outside wire and the neutral being 2,300 volts, and between the outside wires 4,000 volts, the generator is loaded as if it consisted of three separate single-phase machines; 2,300-volt transformers being placed across the neutral and any of the outside conductors, the result is virtually a three-phase transmission at 4,000 volts. Lines in the immediate vicinity of the power-station can be worked from single-phase branches; the neutral should be used simply as a common return where convenient. For cases where the principal loads are found close to the station, but where there are certain long branch lines which it is desirable to operate at high voltage, the author advises low-pressure three-phase generation, the distribution near the station being direct from the generator, and for the long lines through step-up transformers. The alternator is wound for, say, 125 or 250 volts between the outside and neutral wires; standard 220 or 440-volt motors can then be connected to the outside wires. B. P. S.

582. *Working Costs of Isolated Plants.* **I. D. Parsons.** (Eng. Mag. 3. pp. 573–588, Jan., and pp. 721–736, Feb., 1902.)—The author has collected a considerable amount of information in New York, bearing on the expenses of working private plants, several of which were, however, on an extensive scale. The figures for seventeen such installations are given in full, together in some cases with load curves, &c. Each of the seventeen cases is considered separately, and the circumstances in connection with each are noted. The buildings vary from a large block of offices, 20 floors high, standing on ground 70 feet by 100 feet, having 10 lifts, and 575 kw. of plant installed, down to a club, 5 floors high, standing on ground 35 feet by 100 feet, with no lifts, and 20 kw. installed. The cost per unit in the latter case, in which the dynamo was only run from 4 p.m. to 1 a.m., and no battery was used, was about 5d., and in the former case about 2·2d. The original paper should be consulted for particulars as to the results of working in the various buildings considered. The author thinks that on the whole the statistics show the decided advantage of the isolated plant over the central station service. This is said to be more noticeable in the case of the smaller installations, seeing that they would be charged by the central stations at a higher rate, and some further saving is also experienced through heating the buildings by exhaust steam. The question of heating is, from the American point of view, of great importance; and the author thinks that this consideration alone to a great extent justifies the existence of isolated plants in most cases. W. H. S.

583. *Alternating Current Distribution.* **C. F. Guilbert.** (Écl. Électr. 29. pp. 381–391, Dec. 14, 1901.)—This paper consists of descriptions of various recent inventions in connection with the distribution of energy by alternating

currents. Descriptions are given of—(1) An extension of C. F. Scott's well-known method of transforming from two- to three-phase current. In the method now described the transformer is dispensed with, a compensator or auto-transformer being used in its place. (2) A device due to Lamme for varying the pressure in a distributing network where the pressures or the currents are too great to allow of the ordinary methods being used. This is effected by means of a booster in the circuit, the primary of which is supplied from an auxiliary winding on the transformer, of which any desired number of turns may, by means of a multiple contact switch, be brought into use. (3) The method devised by Steinmetz of transforming the frequency of an alternating current by means of induction motors run "in cascade." The rationale of the method depends on the fact that if we have two synchronous motors, of which the rotors are rigidly coupled, the stator of the second machine being supplied from the rotor of the first, and the rotor of the second short-circuited or coupled up to a rheostat, the coupled rotors of such a system will revolve at a speed corresponding to about half the frequency of supply. Two or three modifications of this principle are described. (4) A device of Steinmetz for diminishing the "all day" iron losses in transformers. Two transformers are used, the smaller one of capacity large enough to take the ordinary day-load, and the other for the full night-load. The two have a common pole, both on the primary and secondary windings; from the other poles of the primaries two separate leads run back to the generator, one or both being connected thereto, as may be required. (5) An arrangement devised by Potter for starting up rotaries without the use of secondary batteries. A motor-generator system is used, the motor being fed from the alternating mains. An improvement is to use a generator with two armatures and separate field magnets. One of the machines is employed to excite the field of the rotary which is to be started, and the other for the armature only. (6) Elihu Thomson's constant-current transformer. [See Abstract No. 406 (1902).] (7) To prevent the hunting of rotaries when run in parallel, which he puts down to ohmic drop in the line, W. J. Davis would only run each machine in parallel at light loads, and would provide that as far as possible each machine should at full load be run by its own generator. (8) A method described by A. D. Lunt of electrically coupling two or more alternators of the same frequency, but differing in phase. (9) Elihu Thomson's safety device for cutting a transformer out of circuit in case of the failure of insulation of the transformer or of a similar fault on the line. The body of the transformer or one of its secondary terminals is earthed through the primary of a small auxiliary transformer, which has two secondary circuits connected in series and opposing each other. The free ends of the secondary winding are connected to two balls, each separated by a thin layer of insulating material from a similar ball connected to one of the primary mains. A condenser of relatively small capacity is connected across the primary balls, with its middle point connected to the points of junction of the two secondaries. If a current passes to earth through the primary of the small transformer, a spark passes between the balls, the condenser comes into action, and the fuses blow exactly as if the primary were short-circuited. (10) An automatic circuit-breaker, the invention of Messrs. Reed and Farrar, actuated by an electromagnet. By a slight modification of the design this can be used for either alternating or direct current. The paper is well illustrated by diagrams of the different devices described. B. P. S.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

584. *Electric Light and Power in San Francisco.* (Journal of Electricity, S.F. 11. pp. 269–279, Dec., 1901.)—A station has lately been erected by the Independent Electric Light and Power Company, and is here described. The boiler-house contains eight Babcock boilers, each of a capacity of 500 h.p. The economisers are placed immediately behind the boilers, and on a higher level; there are two rows of them, and they fill out the whole of the double flues leading to the chimney, the steam-pipes passing over the top of the flue to the engine-room. The chimney is opposite the middle of the boiler-house, two flues leading into it from both sides; it is 10 feet in diameter, and 125 feet high, being constructed of steel and lined with firebrick. The engine-room plant includes four 1,500-kw. and one 500-kw. two-phase generators, giving their output at 500 volts and 60 cycles and 116 r.p.m.; also two 100-kw. exciters, and nine 750-kw. step-up transformers, by which the two-phase current is changed to three-phase at 11,000 volts. It is transmitted to various substations, whence it is supplied to the consumer either as direct current on the three-wire system at 110, 220, or 440 volts, or as two-phase alternating current at 115, 230, 440, or 2,300 volts, the substations containing the necessary transforming machinery. The main station, above described, is at Potrero; the power is transmitted by overhead lines for a distance of 4 miles, to a point which appears to be on the outskirts of San Francisco; after this point the high-tension transmission line is placed below the ground. Some of the substations are described, and a further article is to deal with the distributing system more fully. Drawings are reproduced, showing plan, cross-section, and longitudinal section of the main generating station, and there are several good process blocks. W. H. S.

585. *The Waterside Station of the New York Edison Company.* (Elect. World and Engineer, 39. pp. 5–14, Jan. 4; 65–76, Jan. 11; 111–116, Jan. 18; and pp. 191–194, Feb. 1, 1902.)—The new power station of the Edison Company is here described, which generates high-tension alternate current, and transmits it to the numerous substations, where it is converted by rotaries and fed as direct current into the low-tension three-wire network. The Waterside station will generate the bulk of the current used on the system, and some of the already existing stations will supplement it when required, all of them being, however, used as distributing substations. The Waterside station stands on ground 272 feet by 197 feet, facing the East River, the foundations being on bed rock. The boiler-house is 76 ft. by 267 ft. 10 in., and the engine-room is 115 ft. by 267 ft. 10 in. There are two electric cranes, having capacities respectively of 25 and 50 tons. Coal is received at a pier built out into the river, and by means of conveyors and elevators it is discharged into the bunkers, which are built over the boilers, and store 10,000 tons, or two weeks' supply. There are 56 boilers, arranged in two rows on two floors; reckoning 12 lbs. of steam per i.h.p.-hour, they will each develop 1,625 h.p. without forced draught. They were constructed by Aultman and Taylor, and are of the water-tube type. They will work at 170 lbs. pressure, and are fitted with Roney stokers, forced draught being furnished by fan blowers. The stokers and most of the rest of the auxiliary apparatus are steam-driven. There are four steel stacks, each 17 feet in diameter and 200 feet high; they are lined with firebrick for one-third of their height, the remainder being lined with red brick. The lining is carried on rings of angle iron, and an air space of 4 inches is left between the lining and the stack. Steam is delivered

into a 14-inch ring, to which sixteen connections are made from the boiler-house, the boilers being also connected together by pipes which are independent of the ring. All joints are ground to a steam-tight fit, and no gaskets are allowed in any of the high-pressure piping. The condensing water is brought from the river through an intake tunnel, composed of two ¼-inch steel shells, with a space of 15 inches between them filled with concrete. Just before the intake tunnel enters the building it is divided into two parts, each 7 feet in diameter, one running under each row of engines; the water is discharged to the river through two tunnels of oval shape 8 feet high. The engines are by the Westinghouse Machine Company, and are sixteen in number; they are of the marine type, vertical, with one high and two low-pressure cylinders; cylinders 43½ inches and 75½ inches diameter, stroke 5 feet. The low-pressure cylinders only are jacketed, as superheated steam will be used; they run at 75 r.p.m., are capable of giving 10,000 h.p. with a cut-off at ⅝ths of the stroke, and are guaranteed to give their most economical load of 5,500 h.p., with a consumption of 12½ lbs. of steam per i.h.p.-hour. The shaft has a diameter of 26 inches; the cranks are set at angles of 101°, 133°, and 126°; and the flywheel has a diameter of 23 feet, and weighs 90,000 lbs. To facilitate synchronising, the speed can be varied from the switchboard by operating a motor, which shifts the weight on the governor arm. Each engine has a Wheeler surface condenser with cooling surface of 9,200 square feet. The sixteen three-phase General Electric generators give their outputs at 6,600 volts and 25 cycles, the revolving field weighs 130,000 lbs., the armature 125,000 lbs., and the foundation plates 20,000 lbs. There are three exciter sets, each consisting of a 6,600-volt induction motor coupled to a 150-kw. direct-current machine. A battery is also provided, able to excite the fields of all the generators for one hour. The arrangements of the switchboards, switches, bus-bars, &c., are fully described, everything being mounted in fireproof compartments, built up out of brick and soapstone. A large number of drawings and photos illustrate the various devices. High-tension cables are connected to all the substations; the number of feeders taken to each was based on their known loads, the maximum drop not to exceed 5 per cent., and the maximum carrying capacity for continuous load to be 250 amperes per phase. The standard copper section was therefore fixed at 250,000 circ. mils. for each of the three conductors. The company now owns 41 miles of rubber cables, and 28 miles of paper cables, for their high-tension work. The new cables are insulated with paper; each cable contains three conductors of 37 strands, and each conductor has a sectional area of 250,000 circ. mils. when each wire is laid out straight. The paper insulation is $\frac{5}{32}$ inch around each conductor, and $\frac{5}{32}$ inch for the outer insulating jacket; the lead covering is ⅛ inch in thickness, and contains from 2 to 3 per cent. of tin. The test pressure is 15,000 volts alternating current for one hour, and the insulation resistance, when laid in the subways and jointed up, is not less than 300 megohms per mile. There are now sixteen rotary converter substations on Manhattan Island. The rotaries are six-phase and of two sizes, viz., 1,000 and 500-kw. rated capacity. The former give 270-volt direct current at 187 r.p.m., and the latter by means of induction regulators give their output at any voltage between 240 and 360. Storage batteries are used in nearly all the substations. The standard battery contains 150 cells, and has a capacity of 400 amperes for ten hours. For low-tension feeders a lead-covered, paper-insulated, two-conductor concentric cable is used, each conductor having a section of 1,000,000 circ. mils., the whole being provided with six pressure wires. The

conductors have $\frac{5}{32}$-inch paper insulation, and $\frac{2}{64}$-inch lead jacket. The distributors are either 350,000 or 200,000 circ. mils. single conductors, with $\frac{4}{32}$-inch paper insulation and $\frac{4}{32}$-inch lead jacket. They are designed for a maximum working pressure of 750 volts direct current. The articles contain a large number of drawings, particularly in connection with the switchboards and switches. They also include a plan and cross-section of the generating station. W. H. S.

586. *Salford Electricity Works.* (Engineering, 72. pp. 803–807, Dec. 13, and pp. 864–866, Dec. 27, 1901.)—This station supplies continuous current for lighting and traction at the usual pressures. The boiler-house, 221 ft. by 55 ft. 9 in., contains sixteen Lancashire boilers, 30 feet by 9 feet, fitted with mechanical stokers and superheaters Each pair of boilers is directly connected to one engine besides being connected to the 14-inch steam main, which has three copper expansion bends, each bend consisting of two 10-inch copper pipes. There are two chimneys, one at each end of the boiler-house, and two economisers, each containing 800 tubes. The engine-room, which is 221 feet by 44 feet, contains eight 775-kw. dynamos, giving their output as compound-wound machines at 525 volts, or as shunt machines at 480 volts; they run at 100 r.p.m. The compound engines are of the three-crank vertical tandem type by Browett, Lindley & Co., and are described in some detail; the generators have an efficiency 95 per cent., weigh 50 tons, are connected to flywheels weighing 18 tons, and were built by Mather and Platt. There are also three balancers, each consisting of two 25-kw. dynamos running at 600 r.p.m. The travelling crane lifts 30 tons. Coal is lifted by cranes out of the barges, being delivered in boxes holding 2 tons, fitted with collapsible bottoms, and tipped direct into the bunkers, which hold in all 1,600 tons, and are placed immediately above the boiler fronts. Clinker and ashes are removed by an ash conveyor, the arrangements in connection with which are fully described and illustrated by drawings. The article contains drawings showing the plan and cross-section of the boiler- and engine-rooms, the general design of the engines, the arrangement of ash-conveying plant, and several showing the connections on the various switchboards. W. H. S.

587. *Salford Tramways.* (Tram. Rly. World, 10. pp. 692–699, Dec., 1901.)—For description of the power-house, see preceding Abstract. The track is laid with rails, weighing 103 lbs. per yard, delivered in lengths of 60 feet, and manufactured by the Leeds Steel Works. The specification for the composition of the steel was as follows: Carbon not less than 0·5 per cent., silicon not more than 0·06 per cent., phosphorus not more than 0·08 per cent., and sulphur not more than 0·06 per cent. A drawing shows a section of the rail, fishplates, soleplate, and bolts. The trolley wire is of 0000 B & S gauge. W. H. S.

588. *Bermondsey Electricity Works.* (Electrician, 48. pp. 489–493, Jan. 17, 1902.)—This station is worked in connection with a dust destructor, which is made up of six cells, and consumes 50 tons per day. Forced draught is applied to the furnaces, the pressure being created by fans; steam-jets are also fitted. The destructor gases pass through the three Babcock boilers, which evaporate 6,000 lbs. of water per hour; thence they pass through duplicate flues to the chimney, which is 150 feet high. The feed-water is softened in the Stanhope apparatus, and is stored in a tank, holding 10,000 gallons. The engine-room contains one 75-kw. and two 150-kw. continuous-current sets, which are at

present run non-condensing, and exhaust into the chimney. The balancers deal with an out-of-balance current of 50 amperes; the crane lifts 10 tons; and the cells discharge at the rate of 300 amperes for one hour. The feeders are triple concentric cables of 0·25 square-inch section, the distributors are of 0·1 square-inch section, and the arc light lines consist of twin conductor, 0·023 square-inch section. There are 70 double-carbon arc lamps, burning thirty-two hours. A plan and cross-section of the generating station are given. W. H. S.

589. *Melbourne Electricity Works.* (Electrician, 48. pp. 524–529, Jan. 24, 1902.)—In 1891 the municipal authorities started by undertaking street lighting, and put down twenty-four Thomson-Houston 50-light arc dynamos. Subsequently they were empowered to undertake private lighting, and they bought up three companies which had existed for several years in Melbourne. In 1901 they proceeded to build a new station, which is described in the present article. The engine-room is in two spans of 37 feet, and is 96 ft. 8 in. long; it contains two 10-ton cranes. In a basement below the engine-room are placed the surface condensers with the necessary pumps. There are four 350-kw. continuous current sets, and one 200-kw. set. The surface condensers are supplied with water from a tank holding 250,000 gallons, the water being cooled by a Barnard tower, 44 feet high. The Babcock boilers, four in number, each evaporating 12,000 lbs. of water per hour, are fitted with superheaters; the economiser has 240 tubes. The main steam ring is of steel 9 inches in diameter, and the expansion pieces are also of steel. The cells have an output of 1,000 ampere-hours, and are charged by a motor-driven booster. The distributors are of 0·3 square-inch section, with 0·15 square inch for the middle wire. Some parts of the outlying districts are supplied from alternators, which were taken over by the Council when the companies' concerns were purchased. W. H. S.

590. *Mont Cenis Power Transmission.* **Bernasconi.** (Elettricità, Milan, 20. pp. 756–759, Nov. 30, 1901.)—This installation, which is not yet completed, takes water from the Cenischia torrent at Novalese. The minimum flow of water in this is 800 litres per second, but the plant is installed to make use of 1,400, this quantity being assured by damming a lake to form a reservoir. Two stations are built in cascade to utilise falls of 415 and 444 metres. The total h.p. available is 16,000. The lower station only is now in construction, and is supplied by a temporary canal and a conduit of 72 cm. tube 1,250 metres long. The turbines are by Pictet, with horizontal axis, each giving 1,600 h.p. at 500 r.p.m. Their efficiency is 78 per cent. at full load and 62 per cent. at one quarter load. The governors maintain the speed to within 3 per cent., when the load falls suddenly from full to one-quarter load. The three-phase generators by the Thomson-Houston Company give 1,400 kw. each at 500 r.p.m. and 50 $\sim$, at a power-factor of 0·8. Their pressure is 3,000 volts, raised by oil-cooled transformers to 30,000 volts. The power will be transmitted to Turin, a distance of 60 km., by a pole line of 9 mm. copper wires, with a loss of pressure of 7 per cent. G. H. B.

591. *The New York and Staten Island Electric Company.* **M. Loewenthal.** (Elect. World and Engineer, 38. pp. 1053–1058, Dec. 28, 1901.)—This Company carries out electric lighting on Staten Island, and owns 30 miles of single- and double-track railways in the district. It has grown up out of an amalgamation of other concerns. The article describes with drawings the

power-house at Livingston, which contains two 500-kw. and four 300-kw. two-phase alternators, besides one 1,000-kw. and two 250-kw. railway generators. The boilers are by Babcock and Wilcox, and some by Wickes of the vertical water-tube type are now being added. The various machines are of different makes and dates, and represent the results of a long-continued policy of absorption and expansion. W. H. S.

592. *Montgomery Water-Power Plant.* (Eng. News, 46. pp. 418–419, Dec. 5, 1901.)—Water is derived from the Tallapoosa river, 30 miles from Montgomery, Alabama. A masonry dam, 850 feet long and 42 feet high, was built across the river, giving an available fall of 40 feet without canal. There are now installed four pairs of 42-in. McCormick water-wheels on horizontal shafts, each pair generating 1,250 h.p. at 200 r.p.m. These drive three-phase Stanley generators, each giving 875 kw. at 2,000 volts and 60 ∿ , at a speed of 200 r.p.m. The pressure is raised by transformers to 30,000 volts, and the current is transmitted to Montgomery by a pole line 30 miles long with six No. 5 copper wires. In Montgomery the pressure is reduced to 2,300 volts, and the current changed from three-phase to two-phase. A reserve steam-plant of 2,000 h.p. has been installed in the town. G. H. B.

593. *A Power Plant on the Eighth Floor.* (West. Electn. 30. pp. 75–76, Feb. 1, 1902.)—The plant here described is used in a refrigerating store in Chicago, and the whole is installed on the eighth floor of the building, 90 feet above the ground level. This was necessary owing to the fact that the basement was needed for storage purposes, and it was thought that the heat of the boiler and engine rooms would interfere with the working of the freezing apparatus. The plant includes 3 double-ended marine boilers, having diameters of 10 ft. 6 in., together with an economiser, the coal being hoisted by a conveyor ; and there are in the engine room three 75-kw. machines. The engines run at 275 r.p.m., and are of the horizontal cross-compound type, with the cylinders as close together as possible ; the cranks are set at 180 degrees, and the reciprocating parts of the high- and low-pressure sides are equal in weight. No vibration is said to be noticeable. The load consists largely of motors, which are used in driving various machines in connection with the freezing apparatus ; six elevators are also motor-driven, and the lighting of the place is also included. W. H. S.

594. *Rock Island Arsenal Power Plant.* (West. Electn. 29. pp. 333–335, Nov. 23, 1901.)—Power is derived from the Mississippi river, the head varying from $7\frac{1}{2}$ to 11 feet. The dam has 42 openings, but at present only 14 turbines are put down. The vertical shafts of the turbines drive, by bevel gear, a line of shafting extending the whole length of the power house. This is subdivided into sections, so that, by removing the bolts from one or more couplings, the turbines may be run in any desired grouping. The electrical plant consists of two three-phase alternators giving 500 kw. at 60 cycles, 600 volts, with a speed of 200 r.p.m. They have hollow shafts mounted concentrically with the main shaft, and connected to it by flanged couplings. Both fields and armatures are insulated from earth. Two 25-kw. exciters are coupled to the extreme ends of the main shaft. Oil switches are employed on the switchboard, whence feeders are carried in a subway to points 604 and 740 yards distance. Eighty-two motors are employed, ranging from 1 to 75 h.p., the total power being 1,854 h.p. All the motors are of the squirrel-cage type ; those of 10 h.p. or less are switched directly into the circuit, the

circuit-breaker being held by hand. For larger motors starting transformers are employed. Belt driving is used throughout, a countershaft being employed where double reduction is necessary. Oil transformers are used to reduce the voltage to 104 for the inside lighting. For the external lighting the current is transformed up to 2,100 volts, two-phase, series lamps of 50-candle-power being used. Steam reserve plant is provided, and the plant may also be run in parallel with the two-phase supply of the People's Power Company. The article is illustrated with views of the plant. A. E. L.

595. *Electric Power Transmission in Mexico.* **E. Pinson.** (Génie Civil, 39. pp. 377–383, Oct. 12, 1901.)—This paper contains a description of the installation for the transmission of power to Mexico City, from Villada and Fernandez-Leal on the Rio de Monte-Alto, a distance of 35 kilometres, and from Alameda, Chiluca and Madin on the Rio de Tlalnepantla, a distance of 26 kilometres. The alternators are driven by turbines and give current at 440 volts two-phase, which is transformed to 22,000 volts three-phase for transmission. Details are given of the lines with diagrams. H. R. C.

596. *Electrical Plants in Germany.* (Engineer, 92. pp. 528–530, Nov. 22, 1901.)—The article describes some pumping machinery, erected at the Zollverein mine at Caternberg, near Essen, which is said to be very similar to that in the Charlotte Company's mine at Czernitz. The plant of the former mine was erected by Lahmeyer. The motor developes 320 b.h.p., and runs at 60 r.p.m. The rotating part is of the short-circuited squirrel-cage type, and is mounted direct on the pump crank shaft between two horizontal pumps, the pump rods being driven direct by pins on the shaft. The armature is fed by three-phase current, and is 14 ft. 9 in. in diameter. The current is conducted down the mine shaft by two three-phase cables, each of $3 \times 0{\cdot}28$ sq. in. sectional area, and is supplied at 1,000 volts and 25 cycles. The use of starting resistances, slip rings, collecting brushes, &c., was dispensed with by adopting the plan of starting the motor simultaneously with the generator. The dead weight of the water column is utilised by reversing the pump valves to start the pump as a hydraulic motor, and the motor receives a voltage, which rises gradually from zero to 1,000, and in this way an excessive induced current is avoided. The pump room is connected to the generating station by telephone. There is nothing at the bottom of the mine but the main switch, ammeter and fuses. The generating station contains a 300-kw. three-phase alternator, running at 150 r.p.m. In starting, a small independent steam-driven dynamo is used to excite the field, in order to ensure that the pressure of the main generator shall rise in direct proportion to the speed. This avoids any instaneous rise of pressure which would result from a direct-driven exciter at the moment when the latter reached its critical speed. When the steady speed is reached, the excitation is taken over by the direct-driven exciter. The voltage of the exciter is kept constant by a regulator on Jordan's system, the exciter being of such a size that it is capable of doing work in addition to exciting the generator, and this extra work is variable. A diagram is given showing all the necessary connections. After the plant was erected, a trial showed that the engine gave 426 i.h.p. at 142 r.p.m., while the pump delivered 673 gallons per minute against a head of 1,350 feet at 60·2 r.p.m. The actual power utilised in the water column was, therefore, 278 h.p., showing an efficiency of 65·5 per cent. overall.

The central station at Essen is also described. It contains three 1,000-kw.

and two 500-kw. three-phase machines, generating 5,000 volts at 94 r.p.m. The barring gear is worked by a motor, and by noting the current taken by this motor, the state of the friction surfaces of the engine may be at once seen. Essen is situated in the centre of the Westphalian mining and steel industries, and the load consists to a large extent of motors, which are used in engineering works of various descriptions. These motors are very largely of the asynchronous type, and the power factor over the whole system is said to be 0·7. At the three-phase station, erected at Bockenheim, near Frankfort, in 1892, the power factor is now said to be 0·55, and this shows the effect of many motors of an old type, which are still working on the network. The article concludes by stating that in Germany the number of rotary converters is very small as compared with the number of motor-generators, even where tramway work is concerned. W. H. S.

597. *The St. Louis Transit Company.* (Street Rly. Rev. 11. pp. 813–824, Nov. 1901.)—The street railway companies of St. Louis were consolidated in 1899, and since then two new power-houses have been built to replace eleven which then existed, four of which were cable power-houses. The new stations are called respectively the Central and the Northern. The whole area covered is about 12 miles long by 7 miles broad. The Central station has an engine-room 220 feet by 100 feet, and contains four 2,250-kw., three 1,500-kw., and three 650-kw. direct-coupled railway generators, giving their outputs at 550 volts. The speed of the three latter machines is 140 r.p.m., and of the others 75 r.p.m. There are two boiler-houses; the one is 278 feet by 34 feet, containing 14 Stirling boilers, each evaporating 11,000 lbs. of water per hour, and delivering steam into a main 16 inches in diameter; the other is 316 feet by 50 feet, and contains 16 boilers, which each evaporate 20,000 lbs. of water per hour and deliver into a steam main 20 inches in diameter. Each boiler-house has a separate pump-room, placed between it and the engine-room; here are installed steam purifiers, heaters, boiler-feed pumps, tank pumps, cold- and hot-water meters, &c. The southern boiler-house has three steel chimneys, 7 ft. 6 in. in diameter and 160 feet high; the other has one only, which is 202 feet high and a diameter of 14 feet. The joints are butt joints with inside and outside straps; the details of construction, and the thickness of plates, joint straps and rivets are fully set out in the article. The municipal authorities own the monopoly of water supply; hence six wells have been sunk, giving about 100,000 gallons of water per 24 hours, and twelve cooling towers were erected, each 20 feet in diameter and 32 feet high. About 7,000 tons of coal can be stored. In order to meet temporary emergencies the three 650-kw. steam-driven sets are used as boosters; and on one line which has a very heavy traffic for a very few days these three machines have been run in series with the bus-bars, and the pressure raised as high as 1,800 volts. The Northern power station is not yet complete, but will contain two 2,250-kw. railway generators and two 1,200-kw. three-phase alternators, all running at 75 r.p.m. All engine-rooms have 75-ton three-motor cranes. The boiler-house at this station has 16 boilers, each rated at 400 h.p., and fitted with chain grate stokers. The general design is similar to that of the Central station. The Siegrist lubricator system is used, by which oil is supplied under pressure to all the engine cylinders and bearings, the latter of which are water-jacketed. The piping necessary for this system is shown in plan and elevation in one of the drawings. A sub-station is placed at Delmar, about 5 miles west of the Northern Station and 3 miles north-west of the Central station. This substation is 45 ft. 6 in.

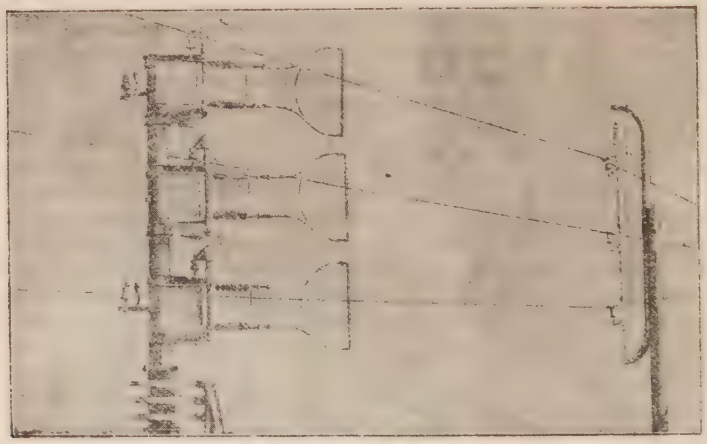
broad and 115 ft. 9 in. long, and contains four 600-kw. rotary converters and thirteen 250-kw. transformers, transforming from 6,000 to 380 volts. A booster will also be erected as soon as the arrangements are complete. The article contains drawings showing plans of the two power-houses, a section of one of the boiler-houses and of a coal-storage building, the arrangements of the Barnard cooling towers, and of the feed piping, besides the connection for the Siegrist lubricator system, already mentioned above. W. H. S.

598. *The Zossen Marienfelde Polyphase Railway Trials.* **W. Reichel.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1369–1377, Sept. 28; pp. 1414–1419, Oct. 5; and pp. 1457–1463, Oct. 12, 1901. See also Elect. World and Engineer for Sept. 7, Oct. 5, 12, 19, 26; and Nov. 2 and 9, 1901.)—These articles contain a description of the experimental trials which have been made by Siemens and Halske on the polyphase railway between Zossen and Marienfelde, a distance of 14¼ miles, with grades ranging up to 1 in 184, and a minimum radius of curvature of 3,280 feet. Experiments were first carried out with a view of determining the effect of wind pressure, as the formulæ in ordinary use give figures which are much too high in the case of speeds exceeding 62 miles an hour. An apparatus constructed on the principle of the anemometer, and driven by an electromotor capable of giving 200 h.p. for short periods, was therefore made. The arms were about 10 ft. 6 in. long, and at the ends of the arms the bodies to be rotated were attached. After some preliminary trials, a body having its front and back ends of a more or less paraboloidal shape was used, the air resistance being then found to be only about one-third of that opposing a flat-ended one. It was finally determined that to propel a car with its end shaped in this manner, and estimated to weigh 94·5 metric, or about 93 British, tons, when carrying the full complement of 50 passengers at the rate of 125 miles an hour, would require 1,000 h.p. The author gives figures showing the way in which the weight is distributed between the various electrical and mechanical portions of the car. Several drawings are given showing the construction of the car and of the trucks for the same. The car is 24 yards in length, the body being carried on longitudinal girders joined together by top and bottom plates formed of U and flat iron connected by heavy iron sheets reaching from the lower edge of the car body to the lower ends of the windows. There are two six-wheeled trucks, and the car body is attached to each truck frame by means of a projecting pin, without the intervention of springs. The truck frames themselves rest primarily upon adjustable spiral springs, from which the load is transferred to long flat springs which rest on the journal boxes. The wheels are 49 inches in diameter, and the motors are mounted direct on the two outer axles, the middle one in each truck being left free to provide space for the supporting frame for the pin in the car body, and for the braking apparatus. A Westinghouse automatic brake is employed, braking the wheels on both sides. A hand attachment is provided, by which the motorman can apply about 80 per cent. of the brake power. The transformers transform from 10,000 volts to 1,150 volts, though the pressure available at starting is 1,850 volts. Each truck has two motors, there being, therefore, four in all for the car, each furnishing normally only 250 h.p., though capable of an output of 750 h.p. in order to obtain sufficiently rapid acceleration. Metallic resistances are used for regulating the speeds; to facilitate cooling these are enclosed in flat cases, placed along the two side walls of the car. In order to make the connections between the resistances and the controllers as short as possible, the controllers are also distributed

along the sides of the car, and are operated by compressed-air mechanism, which is also employed for working the switches. The variation of the voltage obtained from the transformers is effected by varying the connections from star to delta. Each of the two transformers has its three legs laid flat in the direction of the length of the car; in this way it is possible to set up circulating air currents for cooling. The primaries are permanently connected in star fashion. The connections between the switches and transformers consist of bare wire mounted on high-pressure insulators. The air pumps are placed beneath the motorman's platform, and are operated by current supplied by special small transformers. The electrical equipment really forms two distinct units, each one containing two motors, two rheostats, two main switches, two fuses, one large transformer with delta and star switches in the secondary, and primary high-pressure switches, as well as a high-pressure protective device, an air-pump and small transformer with fuses, a trolley, an air reservoir, and a motorman equipment with compressed-air switches and measuring instruments. In case of one equipment being disabled the pressure in the primary circuit of the motors will be raised.

Motors.—The motors have six poles, and a normal speed of about 900 r.p.m. The stator core is undivided, owing to the numerous connections which would be required if it were made in two halves. The case is of steel, and, to facilitate cooling, is made smooth inside and closely fitted to the stator core, both it and the bearing covers being made in two parts to admit of removal for repairs. To the lugs of the lower bearing covers flat iron pieces are bolted, which transmit the turning moment of the motor to the truck by means of springs. No further spring attachment is employed, as it was considered likely to lead to trouble at the higher speeds contemplated. As the heating of the core is mainly in the primary, large radial depth was required to ensure low saturation. To economise space without sacrifice of turning moment the primary was therefore made the rotor, the current being led to it through eight carbon brushes and three collector rings. The rotor winding is of the continuous-current bar type, which enables wire bands to be employed to provide against the high centrifugal tension. *Controller.*—The starting rheostat is divided into 29 steps, 4 primarily to cut in the motor, and the other 25 for the gradual variation of its speed, each step cutting out 20 h.p., the motor output being 750 h.p. at starting, and 250 h.p. at full speed. This can be effected without serious sparking. For each phase of each motor there is one of the flat cases previously referred to, 3·74 feet in length, containing the four starting coils, and another, 5·12 feet in length, for the other 25 coils, the height and width of each being 4 feet and 5·8 inches respectively. They are of angle iron, bolted to the top and bottom car girders, with sheet-iron, shutter-like, ventilated covers. The coils are of "Kruppine" of 1·75 in. by 0·078 in.-section, supported on porcelain insulators, the lower attachments being so made as to allow of expansion. For each phase of each motor there is a controller cylinder parallel to the length of the car and beneath the large cases. The contact-pieces are of bronze and removable, the *a*, *b*, *c* connection being employed to avoid the necessity of 25 regulating contacts for each phase. On the first contact the four motors are cut in in succession instead of simultaneously, which saves resistance material, besides throwing the load on to the station more gradually. The controller is actuated by a differential arrangement consisting of a pair of large and small oppositely acting air cylinders, the smaller one always being under pressure. This gives very complete control to the motorman without

taxing his strength. *Switches and Fuses.*—To divide the current and to enable a damaged motor to be cut out, each motor has its own mean-pressure switch, and a safety fuse for each phase. The switch has a double break of 5·4 inches in each phase, the six contacts being set in a circle with the actuating air cylinder in the centre. A snatch-hook comes into action when the switch is closed, and, when breaking, maintains contact until the air piston has reached its lowest position, thus giving a quick break. The arc is drawn in a narrow insulating tube, and extinguished by a metal cooling ring. The transformer switches, as well as those for the motors, are built for both delta and star connections, one transformer switch being provided for each connection, for each unit of the equipment, so that there are eight switches in all for the four motors. The high-pressure fuses are enclosed in four tubes contained in one large tube of mica. The high-pressure switches differ from the mean-pressure ones in being arranged in sets of three, one-half of the switch being below, and the other half above the roof of the car. The compressed-air arrangement by which they are operated is of the same



general character as for the mean-pressure switches. *Compressed-air Mechanism.*—The air-tanks for the brakes and the switches are located respectively in a corner of the floor of the platforms at each end of the car, and on the ceilings above them, a pressure of 8 atmospheres being employed for the brakes, and 4½ atmospheres for the switches. The tanks at each end of the car are connected by two equalising pipes, and the system is operated from a table on the front of the platform. *Current Collection.*—The trolleys are of the bow type, as shown in the accompanying illustration. It was considered inadvisable to allow any crossings over the line, both because the wires might be touched from the bridges, and because they would necessitate the lowering of the trolleys, which would be undesirable at such high speeds. This decision gave the designers unlimited space above the roof. The trolley pole is formed of two telescoped Mannesmann tubes 7·8 inches in diameter, the lower one being firmly fastened to the floor of the car, and passing through a sleeve bearing in the roof. By means of a hand-brake operating a double set of gears the mast can be revolved by the motorman, and it can be held in its lower bearing by a wedge. At the pper end of the lower tube is a cast-steel flange, surrounded by a hard

rubber sleeve, and to this flange the tube carrying the collector rings is attached. Three contact springs press against these rings as shown, and are attached to hard rubber posts carried by an iron support fixed to the roof of the car. The upper tube is fitted into the hard rubber sleeve on the lower one, and fixed by screws. The trolleys are carried by three revolving sleeves 1 m., or 3·28 feet, apart, on this tube. The enormous wind pressure is prevented from causing the trolleys to leave the wire, both by means of springs and by the use of equalising plates, as shown in the illustration, the wind pressure on which opposes that on the trolley. The collectors are detachable, and of steel tubing as usual. The trolleys are electrically connected to bronze cups carried on the bell insulators above the axes of the trolleys. From them the current passes by contact springs, through lightning arresters of the ordinary fork type, to the collector rings. There are two trolley poles on each car in order to divide the 200-ampere current. *The Trolley Line.*—The trolley wires are carried on wooden poles 35 m. apart, and 2¼ m., or 7·38 feet, from the centre of the track, by means of the link suspension shown in the illustration ; they are 1 m. apart, with the lowest wire 5½ m., or 18 feet, above the surface of the rails. The wires are doubly insulated, each insulation alone being capable of withstanding a pressure of 12,000 volts. One of these is the hard rubber chain at the top and bottom of the bow-shaped iron support which carries the three trolley wires. The second consists of a conical iron bolt 200 mm., or 7·8 inches, in length, surrounded by a hard rubber sleeve 5 to 6 mm., or about 0·2 inch, in thickness. The insulator, also of rubber, is screwed into a thread about 2 inches long at the upper end of the sleeve. The wires are of hard-drawn copper with a section of 100 mm., or 15 square inches, and a conductivity of 97 per cent. of that of chemically pure copper. The 23 kilometres, or 14·26 miles, of line are divided into sections of 1 km., and each section is anchored in the direction of its length. The sections are connected by easily removable wires in the place of section switches. Between any two sections the trolleys leave the wires for a distance of about 10 m., or nearly 33 feet, but as the two battery poles are 17·64 m., or nearly 58 feet apart, the car is never without current. In case of a broken wire the current-carrying wire will be grounded by a device shown in the illustration. At each point of support of the trolley wires is clamped a loop of 8 mm. copper wire, which, if the break occurs in the wire, will be pulled against a copper wire, shown in the illustration, which terminates above in a spring, while its lower end is attached to the rails. Copper cable rail bonds are employed. The rails are connected by a wire to the neutral point, and are earthed by ground plates at intervals of a kilometre. The feeders are of bare wire where possible, with a section of 50 sq. mm. Where cables have to be used the section is 70 sq. mm.

The paper contains a detailed description of the preliminary tests of the electrical equipment. The author calls attention to the fact that it is impossible for the motorman to come into contact with any of the wires, even the insulated ones. G. W. DE T.

599. *Croydon Electric Tramways.* (Electrician, 47. pp. 899–902, Oct. 4, 1901.)—The energy is supplied by the Corporation at the rate of 2d. per Board of Trade unit to the British Electric Traction Company, who have a lease for the undertaking. When completed the total length will be, expressed as single track, 17½ miles. The chief interest is in connection with the Quin system of protection, which is being installed throughout. It primarily consists of an automatic maximum and minimum cut-out in each section of the

line. These sections are separated by the usual insulators. From the negative bus-bar in the Quin pillar, a shunt is taken to the far end of the trolley wire, and connected to it at the sectional insulator. The current through this shunt coil keeps the automatic switch closed, but should the trolley wire break, or the current fail, the switch which connects the feeder to the trolley wire opens, and the section is completely isolated. If a telegraph or telephone wire comes in contact with the trolley wire there is further protection, a series coil is placed between the feeder and the trolley wire, and this acts on the switch, disconnecting the circuit should an excess of current flow through it. The Corporation plant consists of two 300-kw. Belliss-Thomson-Houston sets. A third set of 600 kw. is to be added.

W. W. H. G.

600. *Wigan Tramways.* (Tram. Rly. World, 10. pp. 607–613, Nov., 1901.)—There are at present four miles of track, which are laid with rails, weighing 107 lbs. per yard, on a bed of concrete 8 inches deep, with 2 inches of gravel on the top. The rails are 7 inches deep, and have a base $7\frac{1}{2}$ inches wide; the depth and width of groove are $\frac{15}{16}$ inch and $\frac{3}{8}$ inch respectively. A double trolley wire has been used of No. 000 B. & S. gauge, with three feeders, each of 0·3 sq. in. section. The power station is also described. [See also Abstract No. 1207 (1901).] W. H. S.

601. *New Bedford and Onset Street Railway.* (Street Rly. Rev. 11. pp. 879–887, Dec., 1901.)—This line is about 23 miles long, and is supplied with power from stations at Wareham and New Bedford, which are near the respective ends of the line. The Wareham station contains a 300-kw. and a 200-kw. generator, both belt-driven; also a 250-kw. direct-coupled unit. The New Bedford power-house has more modern plant, consisting of two direct-coupled 800-kw. machines running at 100 r.p.m.; there are in addition two older belt-driven machines. The generators are wound for 750 volts, but current is generally supplied at about 650 volts, for which pressure the motors are wound. The track is mainly constructed of 70-lb. rails in 60-feet lengths, placed on chestnut ties spaced 20 inches centre to centre; Crown bonds are used, and Weber rail joints. The trolley wire is of No. 00 gauge, and is supported partly by brackets and partly by span wires, wooden poles being used in the country, and iron poles in the towns. The article contains several drawings, showing the plan of the station at Wareham, some of the piping arrangements, and a cross-section and plan of the carshed at Wareham. The carsheds are protected by sprinklers in the roof, and by sprinkler pipes under the floor between the pits for fire-insurance purposes, and the pits are heated by steam pipes. W. H. S.

602. *Brighton Tramways.* (Tram. Rly. World, 10. pp. 700–704, Dec., 1901.)—A plan is given showing the routes that are opened; there are $6\frac{1}{2}$ miles in all, mostly double track. The rail used is 6 inches deep, and 7 inches across the base; weight not stated. They are in 36-feet lengths, with a small proportion of 30 feet. A drawing shows a section of the rail and fishplates; and another drawing shows the construction of the joints, in which a 6-inch steel girder transverse sleeper is laid under the soleplate, and crossing the track, connects together the rails on either side; bolts pass through the base of the rail, the soleplate and the top flange of the sleeper. The transverse sleeper is buried in the concrete, which is 12 inches deep at these points; over the rest of the track, the concrete is 6 inches deep under wood paving of

American red gum. The trolley wire is of No. 000 gauge. The tramway power-house adjoins the lighting station, and contains one 325-kw. and two 175-kw. machines. W. H. S.

603. *The Milan-Monza Tramway.* **G. Semenza.** (Street Rly. Journ. 18. pp. 515–518, Dec., 1901.)—The line is 10½ miles long, including 2 miles of city track, belonging to the Milan tramways. From the centre of Milan to the city boundary at Loreto, the track is laid with 93-lb. girder rail; the rest of the track is laid with 53-lb. Vignole rail. The rail bonds consist of two copper wires brazed to the foot of the rail. The brazing is done by making a coil at the end of the bond, and using a hand blower. The author says that an experience of four years in Milan shows that the bonds are thoroughly good, and electrolytic corrosion is so far unknown. Two No. 00 trolley wires constitute the overhead conductors. The line is supplied with power at its middle point from the Paderno-Milan transmission system. Eighteen bare copper wires of No. 00 gauge convey current at 42 cycles and 15,000 volts into the substation, where the pressure is reduced by transformers to 330 volts, and then transmitted to two rotary converters of 200-kw. capacity. The periodicity has been found to be rather high for the satisfactory working of rotary converters. There is also a battery of 280 cells, having an output of 800 amperes for one hour; the positive plates are of the Majert type, and the negative plates of the Pescetto type. The article contains a drawing showing a section and plan of the converter station, and also a section of the car used on the line. W. H. S.

604. *Milford, Holliston and Framingham Street Railway Company.* (Street Rly. Journ. 18. pp. 503–508, Dec., 1901.)—The system includes in all about 40 miles of track. The power station is at Milford, and supplies current both for lighting the town and for the purposes of the railway. The boiler-house contains five tubular boilers, and the engine-room has two belt-driven 125-kw. alternators, giving their output at 2,400 volts and 66 cycles, as well as two direct-coupled railway generators, respectively of 225-kw. and 325-kw. capacity. There are three substations, two of which contain batteries, and the third a rotary converter of 125 kw. The rotary converter substation is connected to Milford by a high-tension transmission line, consisting of No. 4 B. & S. aluminium wire, the power being transmitted at 10,000 volts. There is also a feeder for the direct-current distribution, consisting of aluminium wire, having a sectional area of 360,000 circ. mils., and all the aluminium conductors are carried on the regular trolley poles. The track consists partly of 9-inch 90-lb. girder rail, and partly of T-rail of weights varying from 50 to 60 lbs. W. H. S.

605. *Barmen Rack Railway.* **Daubner.** (Zeitschr. Vereines Deutsch. Ing. 46. pp. 8–17, Jan. 4, 1902.)—The rack railway was opened in 1894, and has become the nucleus of an extensive system of tramways and a light railway, all of which are supplied from a power-house in the lower terminus of the rack railway. The generating plant consists of 5 water-tube boilers of 181·7 sq. m. heating surface each and 5 Elephant boilers of 113 to 130 sq. m. heating surface. The feed water is taken from four wells and passed through a Derveaux water-softener. There are two direct-connected sets of 1,000 h.p. each and two of 500 h.p. The larger engines are of the horizontal tandem type with atmospheric exhaust and trip valve gear. They drive 12-pole shunt-wound generators. The smaller engines are of the vertical cross-

compound type with piston valves for the high-pressure cylinders. They drive internal pole shunt-wound machines. A battery of 260 cells of 750 ampere-hours capacity is used to take up the irregularities in the load. A motor-booster is employed for charging. The power-house feeds in all 35·55 km. of line, including 1·65 km. of rack railway and 4·5 km. of light railway running from the end of the rack section to Ronsdorf. The gauge is 1 m. throughout. The rack railway has a maximum gradient of 1 in 5·4, and a mean gradient of 1 in 9·7. The rack is of the Riggenbach type with 75 mm. pitch and 90 mm. breadth of teeth. The light railway has a maximum gradient of 1 in 25. On these two lines, which are the oldest in the group, shunt motors have been employed with good results. The energy required for an upward journey of a 14-ton car is 11-kw. hours, of which 5·6-kw. hours are returned to the line on the downward journey. The maximum speed allowed is 9 km. per hour. The 14-ton cars carry each two 60-h.p. motors, the 11-ton cars one 85-h.p. motor. In addition to the braking action of the current, the cars are provided with grooved brake drums on the pinion shafts. These can be braked either by hand or automatically on exceeding a certain speed. There are also ordinary brakes on the running wheels. The light railway is worked by cars having two 25-h.p. shunt motors. Goods traffic is provided for by two electric locomotives having each two 60-h.p. shunt motors. The article is illustrated by numerous photographs and diagrams. A. E. L.

606. *Nogent Tramways.* **T. Pausert.** (Écl. Électr. 30. pp. 133–143, Jan. 25, 1902.)—The earlier portions of these tramways, dating from 1887, were worked by compressed air, but this system was not found to lend itself to further extensions, and was abandoned in favour of electric working. The system at present consists of 50 km. of lines serving 20 communes in the vicinity of Paris, with a line running into the city as far as the Place de la République. The power-house is at Vincennes, and contains eight multi-tubular boilers having a heating surface of 106 sq. m. each, and suitable for a pressure of 17 atmospheres. They are capable of evaporating 2,500 kg. of steam per hour each. Reducing valves are employed to reduce the pressure to 8 or 9 atmospheres for the engines. Town water is used for feeding the boilers, and is softened by means of a "Desrumeaux" softener. A deep well is also provided as a stand-by. The engine-room contains two 500-kw. generators and two of 325 kw. The 500-kw. generators are driven by compound Corliss engines, having 600 and 950 mm. cylinders with 1,080 mm. stroke, running at 95 r.p.m., and the smaller ones by single-cylinder engines. The engines exhaust either to the atmosphere or into jet condensers, the water being passed into a cooling tower and used again. The generators are overcompounded to give 500 volts on open circuit and 600 volts at full load. A set of three negative boosters, driven by a 15-kw. motor, are employed for the return cables. The switchboard is provided with two positive bus-bars, allowing different feeders to be supplied at different pressures. The feeders, of 300 and 400 sq. mm. section respectively, are lead-covered and armoured, and are buried directly in the ground. The trolley wires, 9 mm. in diameter, are suspended 7 m. above the ground, and are divided into sections of 1,500 m. connected through switches. They are carried by brackets on steel poles. The track is laid to standard gauge of 1·44 m. The rails are partly of the "Broca" section, weighing 48 kg. per m. with Falk cast-welded joints laid on concrete, and partly of the "Vignoles" section, weighing 25 kg. per m., laid on wooden cross sleepers and doubly bonded with "Chicago" bonds. For a length of 3 km. in the suburbs of Paris, the

trolley is discontinued, and the cars fed on the side-slot system already in use on the other Parisian lines, while in the city itself the cars are driven by accumulators. The cars for city service measure 11·25 m. overall and carry 78 passengers. They have roof seats with a canopy. They are mounted on bogies of 1·22 m., wheel base spaced 3·87 m. from centre to centre. Each car carries two motors of 45 h.p. The battery consists of 210 cells weighing 18 kg. each, and is charged in about nineteen minutes from the trolley wire. For the suburban service the cars are without accumulators, and carry 52 passengers. They are mounted on four-wheel trucks and carry two motors of 35 h.p. Air and hand-brakes are used. At Maltournée, 8 km. from the power-house, there is a 400-ampere-hour buffer battery provided with a booster for charging. A. E. L.

607. *Hamburg Tramways.* **H. Vellguth.** (Street Rly. Journ. 19. pp. 1–12, Jan., 1902.)—A complete description of these tramways is here given. The track is laid with 106-lb. girder rails; the groove is $1\frac{1}{4}$ inches in width and depth, the inner flange is $\frac{9}{16}$ inch wide, and the head of the rail is $2\frac{3}{8}$ inches wide, the base being $5\frac{1}{8}$ inches across, and the depth of the rail 6 inches. The construction is unusual in many ways, noticeably in that no cross-ties of the usual kind are used, but the rails are joined together by a flat rod of peculiar section, which embraces the rail bases by means of extensions, and is secured by wedges. The fishplates are also of special section, and are carried round beneath the base of the rail on both sides. All these features are illustrated by drawings, which also show the standard track construction in streets with and without concrete foundation. It was found that the treads of the wheel-tyres wore more rapidly than the flanges; the expedient was therefore adopted of having the outer rails with grooves $\frac{9}{32}$ inch deep on all curves having radius of less than 33 yards. At these points the outer wheels therefore run on the flanges, and no case has occurred where a car has jumped the rails. Even now the wear on flanges and treads is not equalised, and it is intended to adopt the shallow-grooved rails on the outers of all curves having a radius of less than 80 yards. These shallow rails are also used on built-up crossings. On curves where the shallow-grooved rails are used the gauge is made somewhat tighter, the rule being to make it 1,432 mm. instead of 1,435 mm. The rails are double-bonded with copper bond wire 0·35 inches in diameter. More than half the track is laid on a ballast of coarse gravel or broken stone, of which the latter is preferred. Concrete foundations have only been used where the entire street had such a foundation, and then a layer of asphalt $\frac{3}{16}$ inch in thickness is placed between the rail and the concrete. The switch tongues, which are of Siemens-Martin steel, are 13 feet long and operated by hand. The trolley poles of Mannesman steel are 40 yards apart. On one of the main streets some double-bracket poles are used, though they appear to be placed at the side of the road which borders the harbour. These brackets are 28 feet long, and, being of ornamental design, the poles are said to have cost £500 each. The trolley wire is No. 0 in the suburbs, and No. 000 with a figure 8 section in the town. Recently a wire having a rectangular section, but rounded at the four corners has been introduced. The thickness of this wire is $\frac{5}{16}$ inch, and the cross-section is 158,000 circ. mils. The tension on a No. 0 trolley wire is 400 kg.; when the warm weather approaches small pieces are cut out of the trolley wire at convenient points, and these are replaced in colder weather. The trolley wires on the streets with heavy traffic are replaced every three years. Power is purchased from the town electric lighting company, which owns all

the connecting cables, and is said to be responsible for any damages due to electrolysis. There are in all 33 feeding-points. The rolling stock is also described, and the passenger receipts analysed. W. H. S.

608. *Chicago and Joliet Interurban Railway.* **A. S. Kibbe.** (Street. Rly. Rev. 12. pp. 4–13, Jan., 1902. See also West. Electn. 29. pp. 218–219, Oct. 5, 1901.)—This line consists of 70 miles of single track, with no grades exceeding 5 per cent., and few sharp curves. The rails vary from 40 to 73 lbs., being chiefly 70 lbs. per yard, and are bonded with one "Protected" bond equivalent to a No. 0000 wire at each joint. Most of the track is laid on the highways, on cross-ties, ballasted with limestone 6 inches deep below them, and paved in towns. Span construction is used wherever possible. The trolley wire is No. 000; the feeders are of aluminium cable, part working at 15,000 volts, part at 2,300, and the remainder at 600. The only difficulty with the aluminium cables has lain in their high coefficient of expansion. The generating plant at Joliet consists of two G. E. alternators of 750 kw. each at 60 cycles per sec., 2,300 volts, driven by 12 turbines operated by the River Desplaines. The nearest substation (1 mile) is fed at 2,300 volts; two others, at 12 and 24 miles respectively, are fed with current transformed up to 15,000 volts. On account of the high frequency, induction-motor generators are used in the substations in preference to rotary converters, which are unstable under these conditions. In the distant substations the current is stepped down to 550 volts for the motors. Large storage batteries have been installed at the substations to obtain the best results from the water-power, and the fluctuation of the motor-generator loads is only about 10 per cent. Motor-driven boosters with compound winding are used to charge and discharge the batteries. Commodious buildings have been provided to house the plant. Cars 20 and 30 feet long are used for local services. For interurban traffic, the cars are 36 feet long, on Brill trucks. The wheel base is 6 feet, and the gauge standard. Christensen air-brakes are fitted. Each car is equipped with G. E. 67 motors geared to 40 m.p.h. Normally the cars, which weigh 50,000 lbs. loaded, make the 30-mile run in 80 minutes, including 20 or 30 stops, and use 75 to 90 units. The traffic arrangements are described, and the article is fully illustrated. A. H. A.

609. *Rail Feeder Construction in San Francisco.* **S. L. Foster.** (Street Rly. Journ. 19. pp. 25–26, Jan., 1902.)—The main station is situated on a street having a double tramway line on it, constructed of 62-lb. girder rails. Exclusive of the current brought back by the earth, which consisted mainly of a bonded 20-inch cast-iron salt-water pipe, and an unbonded 30-inch similar pipe, all the current was brought back to the power-house along the double-track road, the joints being bonded with three No. 000 bonds. The rails were connected to the negative bar by four copper bars, each of 1,000,000 circ. mils. section. As the load increased in the process of time from 1,200 kw. to 5,000 kw., the loss in rails and cables became excessive. About 300 yards north and south of the power-house there are two points where the traffic becomes congested, and though the total section of the return paths from these points amounts to about 160 square inches of steel, or about 16 square inches of copper, the maximum current of 10,000 amperes was very uneconomically carried. The copper cables, too, became extremely hot, and at times the sleeve connections were partially unsoldered; at times of heavy load, they were only saved by the chilling effect of streams of compressed air. Moreover, alleged electrolytic destruction of lead service pipe occurred

near the station. It was, therefore, determined to increase the capacity of the return conductor on the street facing the power-house. For this purpose a nest of fourteen old 45-lb. steel tramway rails were laid in a trench along this street for about 600 yards, connecting the points above-mentioned, and where this line of rails passed the power-house it was connected to the negative bar by two copper conductors 1 inch by 5 inches in section. The successive rails of each line were connected by a riveted lap-joint 12 inches long, the joint being also bonded by two copper tubes, $\frac{1}{16}$ inch in outside, and $\frac{5}{8}$ inch inside diameter. The 1 inch by 5 inches copper bars were 10 feet long, and were connected together by lap-joints 7 inches long, and held by eight $\frac{5}{8}$-inch steel bolts. Further details of the construction and of the method of making the various connections are given at length, accompanied by drawings. The current density in the return conductors has now been reduced to a maximum of 500 amperes per square inch. Careful tests were carried out before and after the alterations were made, and it has been found that there is a saving in the power required amounting to $2\frac{1}{4}$ per cent. of the total output of the station. The results were to some extent improved by the fact that after the old rails were connected up, the fishplates and bonds were removed from the double track passing the power-house, and the joints were cast-welded. The average C^2R loss in the return conductors is stated to be only 21·3 per cent. of its previous value, and the estimated saving per annum amounts to 78 per cent. of the total cost of the work. W. H. S.

610. *Surface-Contact Tramways at Wolverhampton.* (Tram. Rly. World, 11. pp. 65–76, Feb., 1902.)—These tramways have been equipped on the Lorain system. At present one mile of track is open for traffic, but the remaining ten miles will be opened in the course of the next few months. The cost of track construction has been about £5,500 per mile, and in addition the cost of the surface-contact system has been about £1,800 per mile, making a total of £7,300. The gauge is 3 ft. 6 in., and the rails weigh 100 lbs. per yard, a drawing being given showing their section. The insulated cable, which is of 0·05 square-inch section, is brought up through the concrete at intervals of 10 feet, this being the distance between the various contact boxes. The cables are laid on the solid system in bitumen; but ordinarily the Lorain Company is said to prefer a drawing-in system. The contact box consists of a base of insulating material, known as reconstructed granite, and a metallic cover, the main portion of which is of iron, and the central part at the top is of specially hardened non-magnetic steel, adapted to resist the wear of the collecting shoe. The contact is made between two carbon surfaces in a hermetically sealed chamber, the rising contact being connected to the feeding cable by a thin strip of hard rolled copper, about $1\frac{1}{2}$ inches wide, folded upon itself. After the car has passed, the contact is broken by the force of gravity. Three drawings are given, showing sections of the contact box. A diagram is reproduced, showing the method of wiring the car, necessary for the Lorain system, and provision has been made for taking current from an overhead line, in case the cars should be run on any such section. The energising coils for the magnet carried on the car have a compound winding, one being in series with the motors, and the other being a shunt winding of the normal tramway voltage. Six cells are carried on the car, which are charged, when necessary, by closing a switch, which places the cells in series with the motor. The cells are used at the moment of starting the car from the car-shed. Three drawings show the arrangement of the collecting shoe and magnets on the car. Power is

provided from the town electricity works, and two units of 825-kw. capacity have been installed for the purpose, the engines being by Willans and Robinson, and the generators by the Electric Construction Company.

W. H. S.

611. *Rearrangement of Power Generating and Distributing Scheme at Worcester, Mass.* (Street Rly. Rev. 12. pp. 33–35, Jan., 1902.)—This paper deals with the problem of economically distributing power over street-railway systems, formed by the consolidation of several independent systems. The case in point is the system of the Worcester Consolidated Railway Company, of Worcester, Mass., which comprises the routes operated previously by seven independent companies. The total mileage of the Consolidated Company is 130 miles of electric railway track, in and about the city of Worcester. It is pointed out that latter-day knowledge would probably advocate for such a system a high-tension alternating-current distribution from a central power-house, with transforming and converting substations near the centres of the outlying loads. The saving to be effected by such an alteration has, however, to be set off against the losses of the original outlay on the various local power-houses, and in this case a careful investigation of the figures did not warrant such a change. What is being done is a rearrangement of the power and storage battery plants, whereby three of the old power plants are wiped out, and the storage batteries moved to points where they afford the greatest assistance in working the combined system. A new 3,000-h.p. Allis engine direct-coupled to a 2,000-kw. General Electric direct-current generator is being added to the main power-house plant at Worcester, and the plant from the discarded stations is in part being moved, to augment the output from the stations which have been retained, and in part sold. The equipment and output capacity of each of the power-houses is given in detail. A description is given of the improvements in the track and cars introduced by the new company, the latter being mounted on Laconia No. 8 B high-speed double trucks, with the patented "perfectly cushioned swing bolster."

J. L. F. V.

612. *Electrical Equipment of Palmer's Shipbuilding Works.* (Engineering, 72. pp. 607–609, Nov. 1, 1901.)—These works were supplied with power by a multitude of small engines, scattered about the shops. These engines have now been replaced by motors; but the long lengths of shafting, and the numerous belts and pulleys have been practically retained in their entirety. Under the old system Lancashire boilers were placed at various points, and supplied steam to an extensive range of steam pipes. The present power plant is placed in an independent building, and contains four Lancashire boilers, and two 750-kw. three-phase alternators, supplying current at 440 volts. The alternators have flywheels weighing 22 tons, and run at 160 r.p.m. Two 25-kw. steam-driven exciters are also provided. There are in all about 80 motors in use, ranging from 50 h.p. downwards, all being of the polyphase induction type. A long list is given of these motors, showing the various machines driven, the method of driving adopted, and the various shops in which the different motors are placed. The smaller motors up to 10 h.p. are started by coupling them direct to the 400-volt mains. The larger ones are started by an "autostarter," which consists of a double-throw switch, worked in conjunction with a pair of small transformers. With the switch in one position, the motors receive current at a reduced pressure through the transformers, which have a series of loop wires from the winding

so that the starting pressure may be suitably adjusted. With the switch in the other position, the motor is thrown, after the start, on the supply mains direct. The installation has been carried out by Clarke, Chapman & Co., in conjunction with the Westinghouse Company. W. H. S.

613. *Electrical Equipment of the Manhattan Elevated Railway.* (Elect. World and Engineer, 39. pp. 76–78, Jan. 11; 117–119, Jan. 18; and pp. 153–155, Jan. 25, 1902.)—The first two of these papers traverse ground already covered in Abstract No. 977 (1901); the third contains a description of the motor equipment of the trains. It was decided to run six-car trains instead of five-car ones as formerly, as a maximum during the hours of heaviest traffic on the more crowded portions of the system. A schedule speed of 14·7 miles an hour was decided on for the local service, based on an average of three stoppages in the mile. This is a considerable improvement on the former steam service, with which the lighter trains had an average schedule speed of only 12 miles an hour. The weight of a six-car train fully equipped and loaded is about 154 tons. The train characteristic was based on an average distance of 1,775 feet between stations, to be traversed in 68 seconds. It was laid out with power on for 30–35 seconds, and with brakes on from 10–12 seconds, the balance being spent in drifting. This would accelerate the rate of 1·3 miles per hour per second until a speed of about 16 miles per hour was obtained. The rate of brake retardation was assumed to be about two miles per hour per second: this allowed for an average consumption of 17 watt-hours per ton mile. The friction losses, estimated at about 12 lbs. per ton, and the acceleration of the rotating parts, together worked out to an amount equivalent to an addition of 20 tons to a 154-ton train, and it was found that the service would require motors of about 800 h.p. per train.

It was at first proposed to operate each train with two motor cars, one at each end of the train, and four trailers, each motor car to be equipped with four motors. In this system, known as the "double-ended" system, a single main-conducting wire is run between the front and rear cars, the four motors being connected in parallel between it and the ground. The controller in the leading car operates in the usual series parallel way, connecting the four motors first in series and then in parallel. For reversing, an electrically actuated reversing switch is used in the rear car, connected by small controlling wires with the leading car. Each motor car has a controller at one end, each being capable of handling the eight motors. The method, however, is open to three objections: (1) the two large controllers occupy valuable seating space above the car floor; (2) each motor car must carry sufficient rheostats for the control of the eight motors, half of the rheostats being normally out of service; (3) complicated switching is required in making up trains. The proposed use of the "double-ended" system was therefore abandoned in favour of what is known as the "General Electric 'Type M'" system of control, which has proved satisfactory in an extended trial on the Brooklyn Elevated Railway. In this system each motor car is equipped with a series parallel controller, consisting of a number of magnetically actuated contact-making and reversing switches. The "contactors," as the former are called, together with a reversing switch, are equivalent to the usual controlling cylinder, but with the advantage that they do not have to be combined in one case, and may therefore be distributed in convenient positions under the car floor. Each Manhattan motor car has 13 contactors, equivalent to 5 notches in the series and 5 in the multiple position in the ordinary form of controller. Forcible rubbing contact on closing, and a

large spring pressure, to give a quick break on opening, are obtained by means of knuckle-jointed movable contacts, the remainder of the opening being effected by gravity. Magnetic blow-outs are employed. The actuating magnets are connected to 9 wires formed into a cable, which is made continuous by couplers between the motor cars and the trailers. These wires are connected to small master controllers at each end of each motor car, and these are connected to third-rail shoes and to the ground, and the operation of any master controller energises the magnets of the contactors successively as desired. The master controllers are fitted with the so-called "dead man" handles, in which a spring-operated auxiliary controller cuts off the power from the train-controlling cable if the motor man moves his hand from the handle. The contactors will then open by gravity, and cut off the power from the motors. With this system two motors are used on each motor car, and a six-car train consists of four motor cars and two trailers, generally made up as follows: (1) Motor car; (2) trailer; (3) motor car; (4) motor car; (5) trailer; (6) motor car. When a six-car train arranged in this manner is divided in the middle into two three-car trains, each component will have a motor car at each end, so that no switching will be necessary at the termini. An additional advantage of this system is the better distribution of load obtainable, with a consequent increase of the possible tractive effort. The motor cars are of the unsplit box frame type, the field frame consisting of a single elongated steel casting of square external section, into which the armature is inserted through a circular opening in one end. The axle boxes are bolted to one side of this casting. The weight of the motor complete with gear and gear-case is about 4,300 lbs. The type has the advantages of great rigidity, with exceptionally extensive bearing surface for the armature, without sacrificing the length of either the armature or commutator. The ventilating openings in the frame are exceptionally large, and it is intended, on account of the dustless character of the Manhattan service, to dispense with the usual cover plates. The armature is built on a hollow spider, with spaces between the laminations, giving ventilating ducts similar to those of a continuous-current generator. It has 39 slots and 195 segments, there being one turn per segment, and 25 between each slot. The fields are insulated with asbestos on metal frames, and the armature bars with mica. The gear reduction is 3·94, the ratio of teeth being 18 to 71. The efficiency is over 90 per cent. between 140 and 200 amperes at 500 volts. Eight motors, with an output of 200 amperes each, will give a six-car train of 174 effective tons, an acceleration of 1·5 miles per hour per second in place of the 1·3 required by the train characteristic. The train control system allows of the express trains being made up entirely of motor cars if desired, instead of with four motor cars and two trailers, which will allow of an increase in the acceleration, if desired, and also in the speed, which would otherwise be limited to about 40 miles per hour on the level. Each motor car is fitted with an air compressor and governor, the former consisting of a two-cylinder pump, coupled to a series-wound 4-pole motor of the same general construction as the train motor. The piston displacement is 20 cubic feet per minute at a speed of 300 r.p.m. The governor operates at any desired pressure between 80 and 100 lbs. per square inch, closing the circuit on a reduction of about 10 lbs. from the opening pressure. G. W. DE T.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

614. *Sprague Multiple Unit System.* **F. J. Sprague.** (Elect. Rev. 49. pp. 969–972, Dec. 13; 1045–1047, Dec. 20; and pp. 1067–1068, Dec. 27, 1901.) —The article commences with a description of the electric elevated railway in Boston, and then gives a detailed account of the multiple unit system on which it is worked. Each car has a complete electrical equipment of motors with their controller, and the controller of each car in the train is worked by a single "master switch" in the front car. This master switch has six positions—the off or normal position, to which the handle is retracted by a spring, in case the operator lets go of it; three running positions for ahead movement, coast, series, and parallel; two running positions for back movement, coast, and series. The master switch is connected by a five-wire cable, running through the train, to three relays for coast, series, and parallel running, and to the two coils which actuate a reversing switch on each car. The relays complete the circuit of a pilot motor which turns the controller. Thus, if the master-switch be turned to the series position for running ahead, the coils of an electromagnet on the reverser switch turns this so as to connect up the motors for forward running, and at the same time actuates the series relay, whereby the controller is gradually turned by the pilot motor, and starts the train by gradually cutting out resistance. When all the resistance is cut out the circuit of the pilot motor is broken by a switch in the controller, and the train continues to run with the motors in series. The parallel relay acts in the same way, except that the controller continues to turn after the resistances for series running are cut out, and connects the motors in parallel, breaking the circuit of the pilot motor only when all the resistances for parallel running have been cut out. The coast relay reverses the pilot motor and returns the controller to its starting-point. There are two other relays, the "automatic stop" and the "throttle." The former is in the reverser circuit, and is therefore energised as soon as the master-switch is moved from its "off" position. If, intentionally or otherwise, the circuit of the master-switch be broken, the reverser returns by spring action to its "off" position, and the "automatic stop" drops, thereby reversing the pilot motor and returning the controller to open circuit. The "throttle" is operated automatically by the current in one of the motors; it retards or stops the forward movement of the controller at any desired current, and so can become an automatic switch for providing a definite rate of acceleration. If either the "throttle" or the "automatic stop" be in an open-circuit position, it is impossible for the pilot motor to move forward, though it can be reversed. The circuits working the pilot motor are supplied with current locally from the shoe of each car. The weight of a complete equipment for one car, including two master switches, one controller, relays, switches, resistances, connections, &c., but without motors, is 1,972 lbs. Each car on the Boston line weighs 59,000 lbs., and has 63½ per cent. of its weight on the drivers. It takes 550 amperes at a maximum, and starts with an acceleration of 1·8 miles per hour per sec. (0·8 m. per sec. per sec.). The maximum speed reached between stations is 46 miles per hour. The energy consumption per car-mile is 4·5 units. Four stations supply the line, having a total maximum capacity of 73,500 amperes at 550 volts [see also Abstract No. 1212 (1901)].

G. H. B.

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[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

615. *Calculations for Electric Railways.* (Street Rly. Journ. 18. pp. 543–556, Dec., 1901, and 19. pp. 45–53, Jan., 1902.)—The articles in question deal with the proposed construction of a railway between New York and Port Chester, and contain a large amount of useful information. The projectors of the proposed railway are under the necessity of proving the convenience and desirability of the railway, as well as of showing that it is practicable both electrically and financially. In this case they were opposed by several existing railways, who alleged in the first instance that the figures set out were incorrect and the proposed scheme impossible; but these allegations were subsequently retracted. The figures and calculations given in the present articles may therefore be taken as being correct; and as they were prepared on an extensive scale, they are of considerable interest. The proposed railway is 21 miles long, and it is intended to run express trains, covering the distance in thirty-one minutes, allowing for ten stoppages. A large number of curves are reproduced, as being part of the evidence of the promoters. The first shows the so-called speed and distance curves for a 400-ampere motor equipment, this being the size selected. From these curves it is possible to see the speed reached and the distance travelled at any time. Next follow similar curves for a 300-ampere motor equipment; but this was not found able to do the work in the allotted time. It may be added that both these curves show the results obtained on the level, and on various up and down grades, up to 2 per cent. The next curve shows the effect of coasting and braking, and gives the relations between instantaneous speeds and distances covered at any moment. The full braking power is taken as being equivalent to a retarding force of 150 lbs. per ton, producing a negative acceleration of 1·6 miles per hour per second. The differences of grade are also taken into account. Then follow two complicated sets of curves, showing the performances of 400-ampere and 300-ampere motor equipments, under varying conditions of gear ratio, allowing also for the difference between express and local trains, and giving coasting and braking curves, with the distances travelled in given times under the different circumstances. The last set of curves, nine in all, shows the variations of speed between the different stations on the line, the kw.-hours consumed on the various portions, the various inclines, distances, curves, &c., and in most cases these curves are plotted both for express, fast, and local traffic. All the curves are well reproduced, and fully explained in the text. It is impossible to analyse them; but the following may be taken as an example of the results shown. On a run between two stations of $1\frac{5}{8}$ miles, with a train consisting of one car weighing 52 tons, the figures are as follows:—

		Express.	Fast.	Local.
Time consumed		2′ 32″	2′ 34½″	2′ 54″
Kw.-hours		13·54	11·12	6·92
Kw.-hours per car-mile		8·34	6·85	4·26
Watt-hours per ton-mile		160	131·6	81·9
Mean speed in miles per hour		38·5	37·9	34
Percentage	Energy	100	82·2	51·2
	Time	100	101·6	113·2
	Speed	100	98·4	88·3

Further, estimates of working expenses, of the cost of construction, and of the probable receipts are given in considerable detail, and there is a verbatim report of the examination of the expert witnesses. The case was evidently got up with great care, and the articles will repay examination. W. H. S.

616. *Car Maintenance.* **T. Millen.** (Street Rly. Journ. 18. pp. 273–276, Oct., 1901.)—The mechanical department of the Metropolitan Street Railway Company, New York, deals with a total of 2,579 cars, exclusive of special sweepers, sand cars, &c. The author describes the conversion of the original cable cars for electrical operation, with illustrations of special features. The standard brake mechanism in use is arranged so that the brake shoes are pulled clear of the wheels by gravity when released. A movable step, operated by the motorman, to enable the car to pass other vehicles in crowded streets, and a reversible sign illuminated from the outside, are described. Every car is inspected daily on coming in from the street, and is overhauled once in two months. The white metal armature bearings are hardened and polished with a hydraulic broach, which has led to diminished wear. All overhauling and inspection is done from below over inspection pits. A. H. A.

617. *Magnetic Field Produced by the Nice Electric Tramways.* **E. Mascart.** (Archives Néerlandaises, 6. pp. 550–554, 1901.)—The observations described in this paper were made at the Nice observatory, which is situated at a distance, horizontally, of 530 metres from the nearest point of the Nice and Contes Electric Tramway, and at a height of 300 metres above it. The effect on the recording bifilar magnetometer was unimportant, consisting merely of oscillations of small period without any disturbance of the mean position. Distortion of the horizontal-force curves could therefore be almost entirely eliminated by means of suitable damping arrangements. This is in accordance with the theoretical deductions made by Rücker's method [see Abstract No. 1600 (1901)], but the vertical disturbance, amounting to a maximum of $\pm 6 \times 10^{-4}$ Gauss, with somewhere about 100 amperes flowing through the line, was several times greater than the possible theoretical maximum. The author attributes this mainly to the fact that the line of route has alluvial soil on one side and rock on the other, so that the assumption that the earth may be treated as a homogeneous conductor becomes wholly untenable.

G. W. DE T.

618. *Magnetic Field Produced by the Paris Electric Tramways.* **T. Moureaux.** (Comptes Rendus, 133. pp. 999–1001, Dec. 9, 1901.)—Magnetic observations were taken at two observatories, 35 km. apart, but in the same latitude, near Paris. The Parc Saint-Maur observatory is nearer to an electric tramway than the other, the Val Joyeux, and in consequence has greater disturbances. The author tried, by damping, to prevent the sudden violent movements of the declination and other needles caused by the stray tramway currents. But this entire elimination was not obtained, as was found by comparison of the records of the two observatories at all times of the day and night (when the tramway was unused). The conclusion is reached that the horizontal and vertical components, as well as the declination observations of the Parc Saint Maur station, are influenced by the stray currents. [See also Abstract No. 2233 (1900).] P. E. S.

619. *Electrolysis by Earth Returns.* **A. Larsen** and **S. A. Faber.** (Elektrotechn. Zeitschr. 22. pp. 1038–1043, Dec. 19, 1901.)—Experiments were made on the tramway lines in Copenhagen to determine the leakage of current from rails to earth, and from earth to gas- and water-pipes. A line was chosen in which the return path for the current had necessarily to take a definite path through the rails or earth. The road was macadamised, and was opened at various points to admit of measurements on the pipes. Measurements

were made at night when no cars were running, and a current, usually of 100 amperes, was sent into the rails at a fixed point from the trolley line. The current in the pipes was made by measuring the fall of potential by a reflecting galvanometer. Careful determinations of the resistance of the pipes were made. These gave a resistance per square mm. section and one metre length, of from 0·83 to 1·02 ohms; this is about the resistance of mercury, or seven to eight times that of pure iron. The pipes were cast iron of English manufacture. A current of 100 amperes was introduced at different points into the rails, and in each case measurements of the current in the rails and in the pipes were made about every 200 metres. With the current entering at one end of the line the total stray current at a distance of 1,080 metres was 14·8 amperes, and of this 7·45 amperes was in the pipes. With the current entering at the middle of the line (total length 1,210 metres), the stray current was 10 amperes, of which 6 amperes was in the pipes. The pipes measured were, for about half distance, a 9-inch water-pipe and a 6-inch gas-pipe, and for the rest of the distance an 18-inch gas-pipe and a 6-inch water-pipe. These were from 1 to 3 metres distant from the rails. When the current was reduced from 100 to 5 amperes the percentage leaving the rails remained exactly the same, as also did the percentage entering the pipes. The total resistance of the rails in the length of 1,210 metres was 0·014 ohms, giving a drop, at 100 amperes, of 1·3 volts. The greatest difference of potential observed between the rails and pipes was 0·74 volt. With cars running the currents in the pipes followed the movements of the cars. At one point the current in a 9-inch water-pipe had a maximum value of 2½ amperes, with an average of about ½ ampere. The paper gives very full particulars of all the tests, with plans and diagrams. G. H. B.

620. *Contal Electric Automobiles.* (Elettricità, Milan, 20. pp. 771–773, Dec. 7, 1901.)—Three types of car are constructed: a Victoria, weighing 1,050 kilos, and capable of a run of 80–100 km.; a phaeton, weighing 1,190 kilos, capable of running 130–140 km., with an 8-h.p. motor, and an omnibus. Their consumption is 70 watt-hours per ton-km. at a speed of 20 km. per hour. The motors, of Gasnier's type, weighing 96 kilos, have two armatures and two field magnets. The controller gives three combinations of these, and the efficiency is over 80 per cent. at all loads between 12 and 120 amperes. The Contal accumulators have pasted plates; a cell of 21 plates, weighing 13 kilos, has a capacity of 194 ampere-hours at a 5½-hour discharge, and gives 29·3 watt-hours per kilo of total weight. G. H. B.

621. *Electric Automobiles.* **R. A. Fliess.** (Horseless Age, 7. pp. 46–51, 1901.)—Electric vehicles seem to operate more satisfactorily when not required to cover as many miles per trip as is required on an average of horse-drawn waggons at present in light delivery service. An electric automobile can be made to travel, say, thirty miles on one charge of its battery, but for commercial work any attempt to obtain such a mileage on one charge of battery as a regular thing would result in an unsatisfactory service. The longest single trip recorded in light-horse delivery service during a period of observation which extended over three months was 25·725 miles. Out of 165 observations the average distance covered per trip was found to be 12·05 miles. An advantage of this short-trip method of operating such vehicles is that the length of time required to charge their batteries after each trip is very much shortened, and it is possible by properly proportioning the work of each electric vehicle to make it cover more miles per day than is required on an

average of waggons drawn by horses. The author records an explosion which wrecked several of the cells of a car, due to a driver igniting a match near the battery box. On public-cab service, unlike a delivery service, the length of a trip on one charge of battery cannot be closely controlled, and is often lost by a vehicle's having to wait to have its battery charged. The present rolling stock equipment of the New York Electric Vehicle Company consists of some 300 vehicles of various styles, and the building now occupied as a station can accommodate at least 700 vehicles if it should be necessary. Three large American cities have over 650 electric vehicles, owned by three companies operating electric-cab services in them. Yet it is not quite four years since the first electric cab was placed in electric service. The maximum number of miles covered in any one day by a single cab is reported at 66½. The greatest mileage made by any one delivery waggon during the month is 1,381 miles. M. O'G.

ELECTRIC LAMPS AND LIGHTING.

622. *Cooper-Hewitt Vapour Lamp.* (Elect. World and Engineer, 38. pp. 503–509, 1901.)—Particulars are given of this lamp from the patent specifications. Stress is laid upon conduction with and without an arc. This lamp depends upon conduction without an arc. Under proper conditions certain vapours and gases may be caused to remain in such a condition as to convey electric currents under the influence of moderate e.m.f.'s after a current has once passed. Materials vary as to their suitability for emitting light, and must be chosen according to their spectrum. Mercury vapour is suitable, but is wanting in red rays. Certain materials added to the lamp during manufacture make it possible to start the lamp with a moderate pressure. One such substance is sulphur and its compounds, for example, sulphide of mercury ; also selenium and phosphorus with mercury. The tube containing the mercury and sulphide is heated and exhausted, when it is subjected to a current at high voltage. A sulphide differing from the ordinary red or black is formed, and when cool the tube may be worked with a much lower e.m.f. It is desirable to free the tubes from certain foreign substances, particularly oxygen. Iron is generally used for the electrodes. While being exhausted the lamp has applied to it a moderate e.m.f., such as 110 or 220 volts, in addition to the higher voltage, and as soon as current passes from the low pressure, as shown by a sudden intense luminosity, it is known that the process is nearly complete. When the lamp ceases to give off further foreign gases it may be sealed off. When a lamp is to be started without heating on low voltages, it has been found advantageous to surround the glass near one electrode with conducting material, such as foil, which is electrically connected with the other electrode. For alternating currents, two bands are used, one near each electrode. These bands reduce the effective starting resistance of the lamp, so that a lamp which without it will start only on a high-tension circuit will with such a band start on a low pressure without difficulty. When the lamp is once in operation the band does not seem to produce an effect to the same extent.

Several designs of lamp are illustrated. One of these consists of a tube about ¾ inch in diameter and 2 or 3 feet long, the upper electrode being an inverted cup of iron (generally the anode) and the lower electrode of mercury. Flickering is avoided by exposing only a small part of the mercury surface as an electrode. The self-regulation of such lamps depends upon the vacuum.

The conductivity of a gas depends upon the density, increasing as the density decreases to a certain point, and then decreasing. As the pressure increases with rise of temperature, *i.e.*, with increasing current, it is possible to select the pressure and form for radiation, so that the conditions are stable with a certain variation of voltage. W. R. C.

623. *Improved Apparatus for Arc-Light Photometry.* **C. P. Matthews.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 671–683, 1901.)—The author describes an equipment which shortens the process of arc-light photometry considerably, by using the method of producing, upon the photometer screen, an illumination proportional to the mean spherical, or to the mean hemispherical, intensity of the source. Similar methods are due to A. Blondel and to E. J. Houston and A. E. Kennelly (see L'Éclairage Électrique, 1895, and The Electrical World, 1896). The author's equipment was designed for the Photometric Laboratory of Purdue University, where it is now in satisfactory operation. The apparatus, while embodying certain features of Blondel's arrangement, combines simplicity of operation with adaptability to either open or enclosed arcs. The author describes in detail the theory of the method employed, and gives numerical examples for further elucidation. From the formula deduced it follows, that to produce on the photometer screen an illumination proportional to the mean spherical intensity of the source, it is necessary (1) to direct towards the photometer the beam of light which the eye of an observer would receive if he were to view the source at an angular interval of 15 degrees in a vertical plane, and (2) to reduce the intensity of the light in these directions in the ratio of the sine of the angle between the direction of view and the vertical. The method of accomplishing this is described by the author, by the use of a ring of twenty-four trapezoidal mirrors which direct the light to the photometer screen in the chosen directions, and by a polygonal glass disk composed of as many sectors as there are mirrors. These sectors are smoked until they give the desired absorption. The possible sources of error are considered, and the means of avoiding them indicated. An essential condition to the success of the method is that the photometer should receive light through any given sector from the image in the corresponding mirror and no other. This condition, the author shows, can easily be satisfied. After determining the constants for the mirrors, glass, rotating wheel, &c., and describing the other parts of the apparatus, the working equation of the apparatus is given in a very simple form. As a check on the accuracy of the integrating method, as compared with the usual method, the author gives the results of a test on an arc of the enclosed type. The value obtained from the Rousseau diagram is 308, that by the method described in his paper 319, an agreement within 3·4 per cent. Considering the difficulty in maintaining an automatic-feed arc under constant conditions during the time required to take the distribution curve, this agreement is very satisfactory. As an appendix to the paper, the graphical method of Rousseau is described and illustrated. [See also Abstracts Nos. 542 (1899) and 2347 (1900).] L. G.

624. *Crawford-Voelker Incandescent Lamp.* **F. Z. Maguire.** (Elect. Rev. 49. pp. 915–916, Dec. 6, 1901.)—This lamp has a filament of titanium carbide, and is bifurcated, the two ends of the filament being separated by glass, which prevents any discharge taking place at the higher pressures. They can be made for pressures as high as 500 volts. A report by H. C. L. Holden,

as the result of running 50 lamps, gives the efficiency as 2·535 watts per candle at starting, 2·845 watts after 500 hours, and 3·35 watts after 1,000 hours. W. R. C.

REFERENCES.

625. *Three-wire Distribution.* **P. Torchio.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 849–856, Nov., 1901.)—The author summarises the points for and against this, and makes elaborate estimates as to the saving of copper in towns. M. O'G.

626. *Organisation of Operating Department of Niagara Falls Power Company.* **P. P. Barton.** (Cassier, 21. pp. 179–205, Jan., 1902.)—A well-illustrated paper by the superintendent of the operating department. G. W. DE T.

627. *Drawbridge at New Bedford, Mass.* **W. F. Williams.** (Street Rly. Rev. 11. pp. 843–846, Nov., 1901.)—A description of the construction and operation of an electrically worked drawbridge, carrying an electric railway connecting New Bedford and Fairhaven. W. H. S.

628. *Accelerometer for Tramway Work.* **F. B. Corey.** (Street Rly. Rev. 11. pp. 889–890, Dec., 1901. Paper read at the N.Y. meeting of the American Society of Mechanical Engineers, Dec., 1901.)—The author describes an instrument which appears to be identical with that devised by Kapp, and already noticed in Abstract No. 723 (1901). W. H. S.

629. *Manufacture and Testing of Incandescent Electric Lamps in the United States.* **B. V. Swenson.** (Cassier, 21. pp. 237–246, Jan., 1902.)—The paper contains an illustrated description of modern methods, together with historical notes. G. W. DE T.

630. *The Burgdorf-Thun Electric Railway.* **H. Martin.** (Génie Civil, 40. pp. 164–176, Jan. 11, 1902.)—This article contains a very complete description, with many sectional drawings and photographs of the railway, which was described in Abstract No. 765 (1900). G. W. DE T.

TELEGRAPHY AND TELEPHONY.

631. *Portable Baudot Installation.* **G. Robichon.** (Journ. Télégraph. 25. pp. 317–321, Dec., 1901.)—The Baudot telegraph was described in Abstract No. 1461 (1901). This paper treats of arrangements of a temporary character, such as that at Dunkirk for the Czar's visit. Two quadruples are coupled and their two distributors are commanded by the same electromotor. One of the quadruples transmits by its four sectors, the other by three sectors, receiving by the fourth. If necessary, however, more sectors can be used to receive. Translators with their electromotors are utilised when required. The two coupled quadruples are on two lines going to the distant station, where they communicate with two quadruples of normal type independent of each other. For permanent offices large Callaud batteries have been used, but something light was called for in the case of portable offices. Hence the Daniell was fixed upon. A copper cylinder is the containing vessel, 4 cm. in diameter and 15 cm. in length, holding solution of copper sulphate ; in this stands a porous pot of parchment paper containing a zinc rod 7 mm. in diameter, with its solution of sulphate of zinc. The internal resistance is under 2 ohms. The battery of 20 to 25 cells, is emptied and refilled daily. E. O. W.

632. *Wireless Telegraphy.* **H. Poincaré.** (Bureau des Longitudes, Ann. 1902, pp. A.1–A.34.)—In the course of a general historical sketch, the author discusses the effect of the antennæ, and attributes their value in long-distance transmission mainly to the fact that the increase of diffraction with wave length enables the longer waves to turn obstacles with greater facility, and, for example, to follow the curved surface of the earth. This would be in accordance with the experimental facts that the Hertz waves are transmitted more easily oversea than overland, and that they do not penetrate to any considerable depths below the surface of the ground. [See Abstract No. 1016 (1901).] G. W. DE T.

633. *Telephone Cable with Self-Induction.* **F. Breisig.** (Elektrotechn. Zeitschr. 22. pp. 1046–1050, Dec. 19, 1901. Communicated by the Telegraphen-Versuchsamt.)—The Kabelwerk Rheydt A.-G. constructed a cable of 28 double conductors, seven 2 mm. in diameter, and the rest 1·5 mm. To increase the self-induction, the wires of each pair were separated as much as possible, and certain cores consisted of a copper and iron wire twisted together. The article describes measurements made on the cable of the resistance, self-induction, and capacity. For the 1·5 mm. iron and copper cores, the resistance was constant for alternating currents varying in frequency from 330 to 900 $\sim$. The self-induction was 0·000422 henry per km., and the capacity 0·0644 mf. per km. For the 2 mm. iron and copper cores, these quantities were 0·00041 and 0·0852 respectively ; for the 2 mm. cores of copper only, they were 0·000296 and 0·0870 respectively. The values were found to vary considerably in the length of the cable. With suitable instruments, conversation over a length of 96 km. was satisfactory, and the authors consider the introduction of self-induction in the form described as a distinct improvement. G. H. B.

SCIENCE ABSTRACTS.

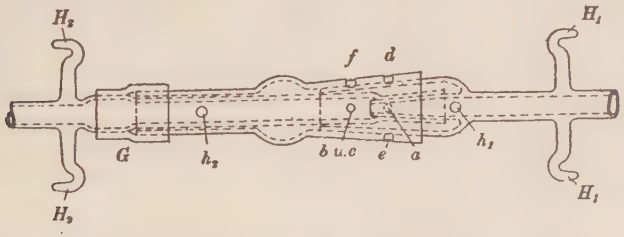
PHYSICS AND ELECTRICAL ENGINEERING.

APRIL 1902.

GENERAL PHYSICS.

634. *The Minarelli Ballistic Pendulum.* **M. Radaković.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 511–518, May and June, 1901.)—This type differs from the ordinary pendulum in that the projectile strikes a hard steel plate. No impression is made on this plate, but the bullet is shivered to pieces. Objection to the pendulum has been made on the ground that velocities obtained by it must be too low. The author points out that after impact the fragments of the projectile fly off at right-angles to their original direction of motion, and proves from this that the velocities obtained are not less accurate than those given by the ordinary form of ballistic pendulum. He remarks that the Minarelli instrument is very suitable for determining the velocity of a shot very close to the muzzle of the gun, and points out the need for experiments on this subject. W. S.

635. *Mercury-sealed Horizontal Stop-cock.* **G. W. A. Kahlbaum.** (Zeitschr. Instrumentenk. 21. pp. 265–266, Sept., 1901.)—This contrivance consists of three pieces, shown in position in the accompanying figure, with



conical ends to facilitate close contact. Two of these fit into one another, while a third forms a sleeve enclosing both. Rubber bands round the hooks H_1, H_2 press the parts firmly together endwise, and a piece of rubber tubing is slipped over the join at G. Three holes, *a*, *b*, *c*, are pierced in the piece to the right (*b* and *c* being in the same cross-section), and three corresponding holes, *d*, *e*, *f*, in the sleeve, so that either of the pairs *ad*, *bf*, or *ae*, *cf* can be

made to communicate. In practice, the sleeve is rotated round the right-hand section till the holes *a* and *b* come opposite to *d* and *f* respectively. Mercury is then admitted at one opening, say *ad*, and the air escapes at the other, *bf*. Then the sleeve is rotated through 90°, which closes all the openings. To open, turn the sleeve 90° further, which brings the holes *e* and *f* over *a* and *c* respectively. Air then enters at *ea*, and the mercury escapes through *fc*. Karl Kramer, of Freiburg, Basle, is the maker. A. E.

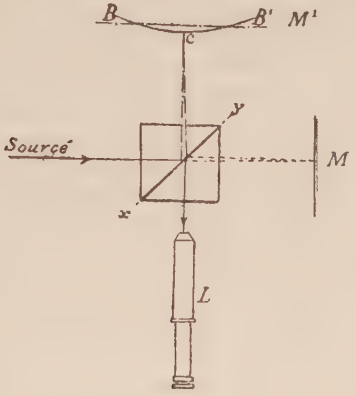
636. *Aneroid Barometers at Low Temperatures.* **H. F. Wiebe** and **P. Hebe.** (Zeitschr. Instrumentenk. 21. pp. 331–333, Nov., 1901. Communicated by the Physikalisch-Technische Reichsanstalt.)—Tests made in connection with the German South-Polar Expedition. Eighteen German, four French, and two English aneroids were tested between +22 and −15° C. at air pressures of 760, 590, and 410 mm. The non-compensated instruments naturally give greater temperature coefficients, and these coefficients increase as the barometric pressure is reduced, also at low temperatures. But the variations in the temperature coefficients are less regular, and may be positive or negative, in the case of compensated instruments, so that aneroids must so far be considered to be less reliable for low-temperature observations than for ordinary work. It resulted, on taking the instruments to pieces, that these sudden irregularities are probably due to the combination of brass and iron in the base plate; base, pillars, and levers should be made in one material only. H. B.

637. *Portable Transit Instrument.* **A. Fennel.** (Zeitschr. Instrumentenk. 21 pp. 326–328, Nov., 1901.)—The instrument, which is made by Otto Fennel Söhne, of Cassel, fits into a box 34 × 26·5 × 26·5 cm., and weighs, with the box, 13 kg. The hard steel rings, with which the horizontal axis rests in the Y bearing, are the only parts constructed of a material liable to rust. The eyepiece can be shifted longitudinally through 2 mm. without turning about its axis; the eyepiece head can be turned through a few degrees, and the hair-cross can be shifted laterally, and easily be replaced. H. B.

638. *Portable Cavendish Apparatus to Demonstrate Mass Attraction.* **M. Kohl.** (Zeitschr. Instrumentenk. 21. pp. 328–330, Nov., 1901.)—A modification of the Boys arrangement, made by Max Kohl, of Chemnitz. A tripod supports a column consisting of a glass case, a wide brass tube, and a narrow one 40 cm. high, in which a quartz thread, 0·005 mm. in diameter, is suspended. The beam, which is of glass, bears two brass balls, weighing 0·75 kg. each, 36 mm. apart, and is provided with a mirror. The column is placed within an iron frame to be fixed to the wall, on which two lead balls, of 3 kg. weight each, can be shifted through a range of 36 mm.; the distance between the centres of a large and a small ball is 53 mm. for zero position. There is a window at either end of the glass case, and a convex mirror outside magnifies the deflection. H. B.

639. *Optical Testing of Linearity.* **G. Lippmann.** (Comptes Rendus, 134. pp. 17–18, Jan. 6, 1902.)—A movable carrier is guided by the sliding base or scale whose rectilinearity is to be tested. A lens is carried in this way to various points, and by it is viewed another coaxial lens fixed in position. The parallelism of the carrier in all positions indicates the rectilinearity required. J. W. P.

640. *Optical Comparator for End Standards.* **A. Lafay.** (Comptes Rendus, 133. pp. 867–869, Nov. 25, 1901.)—The paper describes an arrangement in which Govi's camera lucida is employed in a comparator for end standards, with the advantage that the contact planes are virtual, so that injury from rubbing, hitherto a drawback to the use of end standards, is avoided. L in the accompanying diagram is a telescope, M a mirror, *xy* the Govi cube [see Abstract No. 1415 (1900)], and BB the polished spherical end of the standard rod, which acts as a second mirror. When the plane M′, which is the virtual image of M in *xy*, cuts BB′, a system of coloured interference rings is seen in the telescope. By adjusting the distance of M from the cube, the central white ring is reduced to a spot. The plane M′ will now be



tangential to the end of the rod. By means of a duplicate arrangement at the other end of the rod a similar operation is performed at that end also. The positions of the mirrors, which are moved by micrometer screws, are then read off. If the standard rod be removed, and a copy put in its place, the mirrors will have to be adjusted afresh, and the algebraic sum of their displacements will be the difference in the length of the rods. A. E.

641. *Necessity for Postulating an Ether.* **B. Hopkinson.** (Phil. Mag. 3. pp. 123–126, Jan., 1902.)—The author argues that the phenomena of gravity, together with optical and other terrestrial phenomena, fail, with one exception, to give any logical non-metaphysical basis for postulating the existence of an ether. This one exception is the consequence of the undulatory theory, that the aberration of a star depends on the motion of the earth relative to the free ether, and is entirely unaffected by the motion of the star, which, if capable of experimental proof, would give such a logical basis. Now certain stars, known as spectroscopic binaries, though appearing single when viewed through a telescope, are inferred to consist of two components revolving one about the other, because of the periodic doubling of certain lines in their spectra. This would occur, owing to the Doppler effect, when one component of the system is moving towards, and the other away from, the earth. The orbital velocity, which can be computed from the separation of the lines, amounts in some cases to as much as 150 miles per second. If the motion of the components affected their aberration, then, when moving as above, there should be a lateral separation between the components as seen in a

telescope, resulting in a periodic doubling alternating with the separation of the spectroscopic lines. The fact that no such doubling can be detected affords, in the author's opinion, very strong, if not absolutely conclusive, evidence that the aberration is unaffected by the motion of the star, and gives a real logical basis for postulating the existence of an ether.

G. W. DE T.

642. *Theory of Elasticity.* **W. Voigt.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 52. pp. 1266–1269, Dec. 12, 1901.)—After referring to the work of Kohlrausch and Grüneisen [see Abstract No. 271 (1902)], the author considers the bearing of these experiments on his own general theory, stated seven years ago. Expressions for the elastic potential are stated, with additional terms of the third order, in terms of the primary invariants. The new observations show that these are insufficient and that further development is needed. This is confirmed by O. Thompson's observations (Ann. d. Physik, 44. p. 555, 1891). The expression for the potential needs therefore terms of the fourth order at least, and even these are sometimes insufficient. The formulæ thus become very complicated, and methods of successive approximation are necessary. As a general conclusion, all elastic deformations which can be observed are capable of being expressed by series which proceed by increasing integral powers of the applied forces. In general all terms of even order disappear from such series, provided that that of the second order vanishes. This happens in the expressions for the bending and torsion of rods, except in certain cases not commonly met with in practice. The series for linear or cubical dilatation (push or pull) will proceed by all the powers; but for bending or torsion, in general, by uneven powers only. J. W. P.

643. *Barometric Oscillations on the Sonnblick.* **A. v. Obermayer.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 289–333, April, 1901.)—The harmonic analysis is given of fourteen years'—and more particularly the ten years 1887 to 1896—barometric observations on the Sonnblick, 3,106·5 m. above sea-level, with special regard to serene and cloudy days. Pernter's conclusions concerning the barometer at high altitudes are confirmed. The often insignificant morning minimum at 4 a.m. in the plains is well characterised in the mountains and delayed to 5 a.m. in March and June, 6 a.m. in October, and to 6h. 20min. in December and January. The forenoon maximum at 10 a.m. is delayed to 11 a.m. in November and further delayed to 1 and 2 p.m., and later still in summer, receding again after July. The (4 p.m.) afternoon minimum of the plains is of secondary importance on the Sonnblick, while the evening maximum of the plains is the chief maximum on the mountains, and occurs at the normal time, 10 p.m.; it becomes especially pronounced as the season advances from February to May. On serene days the morning minimum and the maximum of the forenoon (or afternoon) are most noticeable, while the afternoon and evening oscillations are less characteristic. On cloudy days the evening maximum is most marked, and the deviation from the mean daily barometer at midnight is much more striking than on serene days. H. B.

644. *Temperature Variations in the Atmosphere.* **L. Teisserenc de Bort.** (Comptes Rendus, 134. pp. 253–256, Jan. 27, 1902.)—Observations made by the aid of unmanned balloons and kites show that the meteorological variations in the vertical may be very rapid and peculiar. Isothermals are

reproduced for the thirty-five days from Jan. 27 to March 1, 1901, for Paris, extending to elevations of 10 and 12 km. This is the first time that such continued records have been secured. There are instances of temperature inversion, ascribed to insulation of the clouds, and of very low temperatures at high elevation above a high-pressure area. H. B.

645. *Meteorological Observations at Moscow during* 1900. **E. Leyst.** (Soc. Imp. Nat. Moscou, Bull. 4. pp. 397–432, 1900.) — Observations made by the author, director of the University Observatory, Pitschuschkin, and Speranskij. The high barometer of December, 1899, continued to March, 1900, and was followed by an unusually low barometer till June; the November means were abnormally high, those of December low. The diurnal barometer variations are remarkable, especially the high maximum of September and the insignificant minimum of January, February, March, and also June. Daily amplitudes of more than 12 mm. were observed in all the months except July (6 mm. only), but the absolute extremes are not striking. Winds from the N.W. and further S.E. predominated; the Observatory possesses only Wild apparatus, no anemometers. The general course of the air temperature was in accordance with the barometer variations, winter, spring, and summer being all cold; the sky was unusually clouded, and only eight cloudless days (five in August) were reported. The temperature extremes of 3 —7° in December and + 32·6° in July give an annual amplitude of 69·9°, the highest since 1893. July was the only month without frost in those eight years. 596 mm. (533 normal) of rain fell on 196 days, snow on 102 days; thunderstorms occurred only between May and August; 76 cases of solar and lunar phenomena halos, mock suns, &c., were recorded. The soil was never found frozen at depths from 0·8 down to 2·5 m.; observations were made at depths of 0, 0·2, 0·4, 0·8, 1·6, 2·5 m. H. B.

646. *Meteorological Observations at Geneva and on the Great St. Bernard during* 1900. **R. Gautier.** (Archives des Sciences, 13. pp. 55–74, Jan.; pp. 148–181, Feb., 1902.)—The author, director of the Geneva Observatory, includes December, 1899, in his tables, and thus distinguishes between averages for the meteorological and for the civil year. At Geneva, observations are made every three hours from 7 a.m. to 10 p.m.; additional automatic records are obtained at 1 and 4 a.m., and a further evening reading is taken at 9 p.m. to render the tables concordant with those of the Swiss meteorological service, based on observations made at 7, 1, 9—all local time. On the St. Bernard, the brothers take six observations, starting at 5 a.m. during the summer; additional records will be available from the station in the new Hospice building, opened in 1900. The averages of 27 and more years of Plantamour, up to 1875 (Geneva), and 1867 (St. Bernard), are accepted as normal values. 1900 was a warm year, March the coldest month at both stations. The extremes at Geneva were — 9·8° and + 33·9° C., giving an annual oscillation of 43·7° C. against the average 45·8° C.; on the St. Bernard —26·4, March 5, and +19·7°, July 26. The Geneva normal barometer of Noblet is 404·91 m. above sea-level; the Gourdon barometer of the St. Bernard, presented by de la Rive in 1829, is 2,070·3 m. higher up, according to the survey of 1855; the hypsometrical observations of 1900 give a difference of 2,066·7 m. Wind velocities of more than 25 km. (Richard anemograph) were observed thirteen times at Geneva, two maxima of 55 m. occurring on December 9, 1899, and March 31, 1900. The St. Bernard observatory is

not well situated for wind studies, and the wind force is estimated on the Beaufort scale. There are thirteen rain gauges in the canton of Geneva; thunder was heard on twenty-five days; the year was wet in both places, and more mist and less sunshine (Campbell-Stokes apparatus) were recorded than usual. H. B.

647. *Diurnal Variations of Atmospheric Refraction.* **V. E. Boccara.** (N. Cimento, 2. pp. 204–211, Sept., 1901, and Memorie della Società Spettroscopisti Italiani, vol. 30, 1901, pp. 162–178.)—The author's observations were made at Catania, on the coast of Sicily. It had been noticed that the sea horizon changed its position relatively to buildings in the city, and this suggested the method followed. By means of a telescope, the height of the horizon was measured with respect to a fixed landmark comparatively near the observer. A curve illustrating the results is given, together with other curves showing the meteorological conditions during the same interval. It is seen that the refraction is a maximum about 8 a.m., decreases rapidly from 8 till 11.30, then remains pretty constant till 3 p.m.; and towards dusk increases slowly again. The mean value was smaller when the sky was clear than when it was cloudy. On the whole the values were small. While no close connection can be traced, it appears that decrease of pressure, presence of aqueous vapour, and increase in difference of temperature between the place of observation and the sea horizon, all tend to increase the refraction. Putting $n = 2(d - d_r)/d$, where d, d_r, are the true and apparent dips, the results give $n = 0{\cdot}1073$, which agrees fairly well with the value $n = 0{\cdot}1026$ obtained by Soler at Palermo in 1899 by a more difficult method. A. E.

648. *Hertzian Rays and the Sun.* **C. Nordmann.** (Comptes Rendus, 134. pp. 273–275, Feb. 3, 1902.)—An investigation at the top of Mont Blanc gave negative results, no such radiation being found. A. D.

649. *Cooling of very Hot Stars.* **H. Kayser.** (Astrophys. Journ. 14. pp. 313–316, Dec., 1901.)—In the spectra of certain stars which show both bright and dark lines of hydrogen, Campbell found that the lines of longest wave-length are always the brightest, and that there is a transition through the spectrum to the darkest, which are those of shortest wave-length, and he considered that these stars are in a state of transition between Vogel's 1a and 1c classes. If e be the coefficient of emission from a radiating body 1 for a certain wave-length, and E that of an absorbing body 2, whose coefficient of absorption is A, then by Kirchhoff's law $E = e'A$, where e' is the coefficient of emission of a perfectly black body at the same temperature as the body 2. Also the body 2 must be colder than the body 1 to render absorption possible, and thus $e > e'$. While the body 1 is emitting the amount e the body 2 absorbs the quantity eA and emits $e'A$, and therefore the total quantity we receive is $e - (e - e')A$. The amount of reversal depends on the relation of $(e - e')A$ to e, and it is quite possible to have the bodies 1 and 2 at such different temperatures that all the spectral lines will not be reversed, but only those in which $(e - e')A$ is large enough. From the emission curves of perfectly black bodies the ratio $(e - e')/e$ is found to be small for long wave-lengths, and to increase to almost unity for short wave-lengths. Therefore, although E, and therefore A, decreases along a series of lines, the change in $(e - e')/e$ is sufficient to cause the reversal of the lines of shorter before those of longer wave-length. In this way the author thinks the temperature of the absorbing layer might be approximately arrived at, as its emission should

reach a maximum for the rays of wave-length about equal to those at which reversal begins to appear. He therefore estimates these stars at a very high temperature. E. C. C. B.

650. *Variable Stars of Long Period.* **E. C. Pickering.** (Archives Néerlandaises, 6. pp. 133–136, 1901.)—The article gives suggestions for the benefit of general observers having small telescopes, who, by employing some systematic method of observation, may obtain useful results in the field of variable star work when the periods involved are sufficiently long to render small errors inappreciable. An empirical series of comparisons can be used at first, afterwards transferring to standard magnitudes by reduction by aid of the standards obtainable at several of the large observatories. C. P. B.

REFERENCES.

651. *Theory of Girders.* **T. Landsberg.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1765–1772, Dec. 14, 1901.)—The author works out several cases of girders with redundancy due to stiffness at the springings and crown. H. R. C.

652. *Psychrometers.* **J. Schubert.** (Phys. Zeitschr. 3. p. 120, Dec. 15, 1901. Paper read before the 73rd Naturforscherversammlung at Hamburg, 1901.)—The paper contains a comparison of a Schubert psychrometer with an aspiration-psychrometer, gives a formula for absolute humidity, and describes a self-registering wet and dry bulb hygrometer. Both instruments are made by R. Fuess, of Steglitz, near Berlin. H. B.

653. *Applications of Elastic Solids to Metrology.* **C. Chree.** (Phil. Mag. 2. pp. 532–558, Nov., and pp. 594–616, Dec., 1901. Paper read before the Physical Society of London, May 10, 1901.)—An elaborate mathematical and critical paper to which it is hard to do justice in a short abstract. The chief subjects treated are as follows: Effects on solids of suspension and supports, pressure of surrounding medium, æolotropic solids, cylinder suspended from the rim, solid prism with axis vertical, flask containing liquid, hollow bodies containing or surrounded by liquid, standards of length, numerical applications to standards of length and to deflection bars of magnetometers. E. H. B.

654. *Motion of Water through Sand.* **P. Forchheimer.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1736–1741, Dec. 7; and pp. 1781–1788, Dec. 14, 1901.)—This paper treats very fully the rate of flow of water through sand and various filtering media, and gives numerous references to the literature of the subject. W. W. H. G.

655. *Work of Paris Observatory.* **M. Lœwy.** (Revue Scientif. 16. pp. 588–593, Nov. 9, 1901.)—This is the annual report of the director, and gives a *résumé* of the observations made during the past year. C. P. B.

656. *Apparatus for Measuring Variations of Small Zenithal Distances.* **G. Lippmann.** (Comptes Rendus, 134. pp. 205–208, Jan. 27, 1902.) A. D.

657. *Determination of the Apex of the Sun's Way.* **J. C. Kapteyn.** (Archives Néerlandaises, 6. pp. 262–284, 1901.)—A consideration of the conditions necessary for determining the direction of movement of the solar system in space, by reduction of the parallactic displacements of stars in various parts of the sphere, taking into account the possible proper motions affecting the stars used for the investigation. C. P. B.

LIGHT.

658. *Range-finders.* **G. Forbes.** (Soc. Arts, Journ. 50. pp. 78–86, Dec. 20, 1901.)—A portable instrument is described and explained, suitable for use by infantry. Stereoscopic vision is employed to get over the difficulty of "spotting" the object. The aluminium base contains four pentagonal prisms, and the rays entering each end of the base pass through two of these prisms, being twice internally reflected in each before reaching the Zeiss binocular. The base is 6 feet long, and has a hinge in the middle, by means of which the instrument can be folded up, or used with one half of the base acting as a support. The base weighs 2½–3 lbs. and the binocular 2½ lbs. When the latter has a magnifying power of 12 the author claims an accuracy of about ⅓ per cent. at 3,000 yards. In the eyepieces there are vertical marks, one fixed and the other movable by a micrometer screw, the reading of which gives the distance required when the two marks coincide. G. E. A.

659. *Stereoscopic Apparatus.* **E. Berger.** (Zeitschr. Instrumentenk., Beib. 21. pp. 201–203, Nov. 1, 1901.)—This instrument, called by the author a Platoscope, consists in the main of a pair of de-centred convex lenses set at an angle to one another and placed close behind a pair of de-centred concave lenses, which are somewhat less inclined to one another. The focus of the central portions of the systems lies at a certain distance behind the focus of the peripheral portions. If the picture to be observed be placed just inside the central focus, only the middle portion will be seen. If the picture be now brought nearer to the lenses until just inside the peripheral focus, the whole will, after a short observation, appear in perfect relief. The author further recommends the use of this instrument as a form of optometer for testing the eyesight. E. C. C. B.

660. *Periscopic Lenses.* **A. S. Percival.** (British Optical Journ. 1. pp. 54–56, Nov., 1901. Paper read before the British Medical Association.)—Periscopic spectacle lenses are intended to enable the wearer to see objects on either side of him distinctly by moving the eyes only, without moving the head. The author states that the glasses commonly sold as periscopic are hardly worthy of the name, but that he has solved the problem satisfactorily for powers up to +or −10 diopters. The surface next the eye must always be concave, but this causes no appreciable aberration, as the pupil makes the cone incident on the retina of very small dimensions. The outer surface is convex for powers from +20D to −8D, and generally concave for higher myopic powers. Both surfaces are spherical, except in cases of compound astigmatism, when the outer surface must be toric. An optician's estimate is quoted, that periscopic spherical lenses would cost half as much again as ordinary lenses, and periscopic toric lenses not more than twice as much as ordinary sphero-cylinders. A table of radii of curvature is given. The radius of the surface next the eye is made a maximum, viz., 108 mm., for power +5D ; its value for −20D is 32 mm., and for +20D, 50 mm. The mathematical calculations are not given, but will be published in Knapp's Archives. A. E.

661. *Instruments for Measuring Distance between the Eyes.* **E. Dönitz.** (Zeitschr. Instrumentenk. 21. pp. 260–265, Sept., 1901.)—The author discusses the theory of the subject in general, and describes in particular two little instruments recently brought out by Zeiss. The first, and simpler one, intended for self-measurement, is a small flat box to be held horizontally in front of the eyes. Within are a scale and a strip of mirror facing each other. The observer, holding the scale under his eyes, looks over it into the mirror, and fixes each pupil in turn upon its own reflection. For the convenience of those who cannot shut one eye, the central part of the mirror is covered so that neither eye can see the image of the other. The left pupil is placed at the zero of the scale, and it is only necessary to note the reading for the right pupil, which gives at once the distance between the pupils. The second apparatus is chiefly intended for the use of oculists, though it can be employed for self-measurement. It is supported on two connected parallel bars, held by the operator so that a cross-piece at one end is pressed against the patient's brows. The patient looks into a mirror, and by means of a second mirror, the operator sees the pupils projected on the image of a divided scale.

Pulfrich has suggested a method of self-measurement, with a scale and mirror, by holding the scale as far behind the mirror as the eye is in front of it. The scale and vertical image are then at the same distance from the eye, so that the usual trouble from stereoscopic parallax is avoided. The interval between the pupils for converging vision on a point at 250 mm. distance is nearly 4 mm. less than for parallel vision (for eyes 65 mm. apart). With application to spectacles for reading, the author suggests that as the interval for parallel vision is the simplest to measure, it may be best to obtain the interval for converging vision from it by means of tables. A. E.

662. *Aron's Mercury Lamp for Colour Experiments.* **E. Merritt.** (Amer. Phys. Soc., Bull. 2. pp. 30–31, 1901.)—The light from this lamp, being chiefly due to three lines in the violet, green, and yellow, can be utilised for illustrative experiments on colour. For instance, deep red autumn leaves illuminated by the above lamp appear black, but yellow leaves appear deep green, *i.e.*, their actual colour is due to a mixture of green and red. G. E. A.

663. *Focussing a Collimator by Parallax.* **G. Lippmann.** (Comptes Rendus, 134. pp. 16–17, Jan. 6, 1902.)—A point of the image, P say, is viewed through a lens. The lens is then displaced transversely to the line of vision by a distance of (in the case cited) 5 cm. If the collimator is in proper adjustment, P should be at infinity, and therefore the displacement should produce no effect. If, on the other hand, there is parallax, the movement will detect the fact. The accuracy of the method depends on the power of the lens. J. W. P.

664. *Pressure of Light.* **E. F. Nichols** and **G. F. Hull.** (Amer. Phys. Soc., Bull. 2. pp. 25–27, 1901.)—This paper contains a preliminary communication of a measurement of the normal pressure of light waves. The method consists, like Lebedew's, in measuring the angle of torsion of a vane exposed to the light, but the energy of the incident light is measured by a bolometer. The value found was about 80 per cent. of the theoretical value. [See also Abstract No. 1059 (1901).] G. E. A.

665. *An Acetylene Standard of Light.* **C. H. Sharp.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 927–930, Dec., 1901.)—A long series of experiments have been made in the hope of producing a standard of light with a constant flame of a pure gas in a pure atmosphere. A mixture of equal parts of acetylene and hydrogen in an atmosphere of oxygen gave, with the special burner, a flame of great brilliancy and steadiness, but it was found that its intensity was not reproducible from pressure measurements made on the gases. This was found to be due to the unequal solubility of the gases, which were stored over water. The reason for adopting the acetylene-hydrogen mixture was that, with the burner employed, pure acetylene deposited graphitic carbon about the jet with such rapidity as to quickly obstruct the flow of gas. This was not the case with the diluted gas. A new burner was at last found which would admit the use of pure acetylene. In this the acetylene passes through a tube which is surrounded by a water jacket, whilst the oxygen enters a concentric tube outside the water jacket, and issues through the nozzle in a stream surrounding that of the acetylene. With this arrangement there is no troublesome deposit of carbon. The flame so produced is the most brilliant gas-flame known. Its colour admirably adapts it for use as a secondary standard in arc-light photometry. The necessary details of construction and use to convert it into a definite standard have yet to be fixed. W. W. H. G.

666. *The Question of a Standard of Light.* **C. H. Sharp.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 931–934, Dec., 1901.)—It is pointed out that practice is settling down to the use of either a pentane or a Hefner amyl acetate standard for photometric purposes. For gas measurements the former is most favoured, and the latter for electrical work. The careful study of the Hefner lamp in the Reichsanstalt, the adoption of it officially in Germany, the resolution in its favour by the American Institute of Electrical Engineers, and by the Geneva Congress of 1896, have done much to popularise this standard. Nevertheless it would be better to have a standard considerably whiter. Among the ordinary sources of light the acetylene flame probably approaches most nearly in colour to the average light. The propositions of Violle, Fessenden, and Féry to adopt such a standard are mentioned, but no practical definite standard has been the outcome.
W. W. H. G.

667. *Theory of Vision.* **G. Bohn.** (Comptes Rendus, 134. pp. 184–186, Jan. 20, 1902.)—The author controverts Pizon's theory [see Abstract No. 289 (1902)], and upholds a chemical as against a mechanical theory. A. D.

668. *Spherical Aberration of the Eye.* **G. Weiss.** (Comptes Rendus, 134. pp. 98–100, Jan. 13, 1902.)—If a pin-hole is pierced in a card, and a uniformly and well-illuminated surface viewed through it, a luminous spot is seen with a faint but distinct circular shadow in the middle. By diminishing the size of the hole the zone of shadow is made greater in the same proportion. Measurements of an approximate kind are given, and explanation is found in the spherical aberration of the eye, a subject which the author states has received little attention. By contracting the pupil of the eye, or by using a diaphragm so as to cut off marginal rays, the phenomenon can be made to disappear. On dilating the pupil by the use of cocaine, the diameter of the shadow increases. In certain rare cases where the eyes are aplanatic the phenomenon will not occur. J. W. P.

669. *Temperature Regulation of the Stellar Spectrograph, Potsdam III.* **J. Hartmann.** (Zeitschr. Instrumentenk. 21. pp. 313–325, Nov. 1901.)—The error introduced by temperature change into the measurements of the wavelengths of spectrum lines may arise from two sources—first, the change of the refractive index of the material of the prism, and secondly, the expansion or contraction of the metal parts of the spectroscope. It is often very considerable, amounting to, for the spectrograph in question, from 0·212 to 0·222 tenth metres between $\lambda = 4{,}100$ and $\lambda = 4{,}500$ for a change of temperature of 1° C. This change corresponds to a difference of 14·8 to 15·5 kilometres per second in the apparent velocity of a star. Tables are given in the paper showing the rate of cooling and warming of the instrument as determined by measurements made of the iron spectrum. The author has designed a thermostat which keeps the temperature, by an electric regulator, quite constant during long exposures. It consists of a wooden box which entirely encloses the spectrograph when mounted on the telescope. On the two sides of the box directly facing the top and bottom of the prism chamber are two electric heaters in the shape of wire grids, which draw current from the observatory mains at 110 volts. On the top and bottom respectively of the prism chamber is a mercury contact thermometer with adjustable contacts. By means of these two thermometers the flow of small currents from Leclanché cells is governed, which, by means of two separate relay apparatus, control the main current through the heaters. In this way the two heaters are quite independently controlled, each one being provided with its own relay apparatus and thermometer. The maximum supply of electricity to the heaters can be varied by means of incandescent lamps in parallel. A trial of the apparatus gave most satisfactory results, inasmuch as the temperature was kept constant within a tenth of degree for twelve hours though the observatory temperature fell 7°. E. C. C. B.

670. *Visible Radiation from Carbon.* **E. L. Nichols.** (Phys. Rev. 13. pp. 65–80, Aug., and pp. 129–144, Sept., 1901. Paper read before the American Association for the Advancement of Science, N.Y., June 27, 1900.)—The visible radiation from carbon rods in vacuo, rendered incandescent by an electric current, is here compared by means of a spectrophotometer with the radiation from an acetylene flame. Since the radiation in both cases is from incandescent carbon, it was anticipated that a similarity would be found to exist between the spectra of the rods and that of the flame, especially when the rods were heated to very high temperatures. Great experimental difficulties were encountered in trying to measure the temperature of the rods by means of a thermoelectric junction, but these were finally overcome for all temperatures under 1,400°; above that temperature the carbon seems to combine with the metals of the junction, altering their properties. Temperatures above 1,400° were approximately determined by measuring the electric resistance of the rods, and extrapolating in the temperature resistance curve. The experimental results, when plotted, show that the above anticipation with regard to the similarity between the spectra is far from being realised, and that the distribution of energy in the spectrum of the carbon rod, instead of approaching that of the acetylene flame, as the temperature of the rod is increased, assumes an entirely unexpected character. Even at low temperatures, up to, say, 1,100°, the change in the spectrum is not of the simple character which was anticipated, and after passing 1,100°, a surprising complication arises in the results. The energy in the yellow of the spectrum, which from the beginning increases at a relatively more rapid rate than either

the red or the blue, becomes so great as to give to the distribution curve a form entirely contrary to expectation. The isochroms for 0·7μ, 0·6μ, and 0·5μ, when plotted with logarithms of intensity as ordinates and absolute temperatures as abscissæ, are straight lines. J. B. H.

671. *Visible Radiation from Carbon.* **E. Blaker.** (Phys. Rev. 13. pp. 345–368, Dec., 1901.)—This investigation, which was carried out at Dr. Nichols' suggestion in Cornell University, repeats the experiments which Dr. Nichols made on the radiation from incandescent carbon rods [see preceding Abstract], with this difference—that ordinary incandescent lamp filaments were used instead of carbon rods. The temperature of the filament was obtained from a measurement of its resistance by means of le Chatelier's experimental researches on the connection between the temperature and resistance. The spectrophotometric comparison of the intensities of radiation from the lamp filament at different temperatures, with the corresponding radiations from a constant acetylene flame, confirm the general conclusions arrived at by Dr. Nichols—that the radiation from incandescent carbon in the form of rods is different from the radiation from carbon in an acetylene flame. A well-marked maximum of radiation is observed in the comparison curve at a wave-length about 0·62μ, and this maximum is much better marked in the highest temperature curves in the present paper than in those in Dr. Nichols' paper, owing to the higher temperatures to which the filaments could be heated. J. B. H.

672. *Visible Radiation from Carbon.* **E. L. Nichols** and **E. Blaker.** (Phys. Rev. 13. pp. 378–380, Dec., 1901.)—The existence of a selective radiation from glowing carbon found by the authors during their researches on the radiation from carbon rods [see the two preceding Abstracts] has been remarked upon by Brace as probably agreeing with the anomalous dispersion of carbon noted by previous investigators. The authors in the present paper compare the experimental results of previous investigators of the dispersion of carbon, and, as these results seem to vary considerably with the different carbons used, the authors are investigating the subject further. The absorption of a carbon deposit on an incandescent lamp bulb was found by Moore and Ling to be a maximum for the wave-length 0·635μ, which is very near the region of maximum radiation observed by the authors. J. B. H.

673. *Quantitative Spectra of Beryllium.* **W. N. Hartley.** (Roy. Soc., Proc. 69. pp. 283–285, Jan. 31, 1902.)—A tabular statement is given of the spectrographic results obtained with spark spectra of solutions of beryllium of different dilutions, varying from 1 per cent. to 0·000001 per cent. The sensitiveness of the reaction is almost without limit, as with the most dilute solutions the two lines at $\lambda = 3130{\cdot}3$ and $\lambda = 2478{\cdot}1$ were visible with a coil giving a 5-inch spark, and the effect is enormously magnified with a larger coil and condenser. It was found in testing analytical methods of separation of beryllium from aluminium that the alumina persistently showed traces of beryllia. E. C. C. B.

674. *Structure of Mercury Spectrum.* **O. Lummer** and **E. Gehrcke.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 2. pp. 11–17, Jan. 9, 1902.)—This is an analysis of the lines of the mercury spectrum made by interference methods of high resolving power, simply obtained by allowing the light from an electric arc in mercury vapour to fall obliquely upon a strip of plane parallel

glass plate. The rays enter the glass plate, and part of them by a series of reflections traverse the whole length of the plate, but at each point of reflection a certain portion passes into the air, and these refracted rays all pass into a telescope, where they can be observed. The method was more fully described in a previous publication. The spectrum lines of mercury are in this way resolved usually into a principal component with several subordinates; for example, the bright green line has ten such subordinates.

E. C. C. B.

675. *Determination of Absolute Wave-lengths in Spectra.* **C. Fabry** and **A. Pérot.** (Annal. Chim. Phys. 25. pp. 98–139, Jan., 1902.)—The paper describes a series of determinations of the absolute wave-lengths of certain lines by methods of interference. Exception is taken in the first place to the adoption of either of the D lines as a standard, on account of their variable size, and in the second to any solar lines, on account of the relative motions of the sun and the earth. The standard to which the published measurements are referred is the red cadmium line of Michelson and Benoît, $\lambda = 6438{\cdot}4722$ in air at 15° and 760 mm. pressure. The actual method employed was to directly compare the standard ray with the ray in question in an interference apparatus which was more fully described in a previous paper [see Abstract No. 1892 (1901)]. The ray actually used as standard of comparison was the principal component of the green cadmium ray. A series of wave-lengths as determined are given, and in the case of those dealing with the solar spectrum, the values of the ratio of Rowland's numbers to those found are given, and these lie between 1·0000286 and 1·0000381. [See also Abstract No. 2106 (1901).]

E. C. C. B.

676. *Ultraviolet Spark Spectrum of Holmium.* **F. Exner** and **E. Haschek.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 487–507, May and June, 1901.)—The spark spectrum of the element holmium between the limits of $\lambda = 4698$ and $\lambda = 2243$ containing 1,905 lines, the authors had no reason to doubt that their specimens, which were obtained from two different sources, were as pure as possible. In an addendum they modify a statement previously made as regards lines common to the spectra of Samarium and Gadolinium, and in the present paper publish a list of some 30 lines which are of equal but weak intensity in both the spectra. These lines probably belong to a third substance. [See also Abstract No. 1993 (1900).] E. C. C. B.

677. *The Arc Spectrum of Hydrogen.* **O. H. Basquin.** (Amer. Acad., Proc. 37. pp. 161–174, Sept., 1901.)—The paper describes a series of visual and photographic observations of the arc spectra of tin, silver, copper, magnesium, aluminium, zinc, and sodium. The spectra showed the hydrogen lines very diffused, especially towards the blue end of the spectrum. In the above series of metals the first gives the best hydrogen lines, and weakest metallic lines, and the last the weakest hydrogen and strongest metallic lines. Characteristic metallic flutings were, except in the case of tin, seen forming bands, which, with silver, aluminium, and copper, are degraded towards the red, and with the others towards the blue. The wave-lengths of these flutings are given, and the author suggests in explanation the existence of hydrogen-metallic compounds. [See Abstract No. 2101 (1901).]

[It is very interesting to note that the bands given in this paper are identical with the bands given by Hartley and Ramage in their paper on the flame spectra of metals. [See Abstract No. 295 (1902).] This would preclude the

idea of hydrogen-metallic compounds, and also show that the arc in hydrogen and the flame of hydrogen in oxygen are very comparable as means of producing spectra. This is in agreement with Jackson's theory of phosphorescence.] [See Abstract No. 439 (1899).] E. C. C. B.

678. *Structure of the Cyanogen Bands.* **A. S. King.** (Astrophys. Journ. 14. pp. 323–330, Dec., 1901.)—On photographing the spectrum of the carbon arc in air with a long exposure, two new bands were found with heads at $\lambda = 3465{\cdot}69$ and $\lambda = 3203{\cdot}84$, which the author concludes belong to the same series as the cyanogen bands at $\lambda = 3590$ and $\lambda = 3883$. By surrounding the arc with carbon dioxide and oxygen the carbon bands are brightened, but when nitrogen is used the cyanogen bands are slightly strengthened. The author therefore tends to Smithell's view that the carbon bands are due to carbon dioxide. [Smithell's view is that carbon bands are due to carbon monoxide, not dioxide.] E. C. C. B.

679. *Radiochrometer for Röntgen Rays.* **L. Benoist.** (Comptes Rendus, 134, pp. 225–227, Jan. 27, 1902.)—The author proposes to use the results he has already established, concerning the transparency of various substances to Röntgen rays, as a means of giving an experimental definition of the quality of the radiation emitted by a Röntgen-ray tube. [See Abstract No. 1887 (1901).] The transparency of silver to the radiation, as he has already shown, does not alter much with the quality of the latter. On the other hand the amount transmitted by aluminium depends largely on the state of the tube, and hence on the quality of the rays. A disc of aluminium is formed, consisting of twelve sectors, whose thicknesses increase from 1 to 12 mm. The central part is cut away, and is replaced by silver 0·11 mm. thick. The whole is backed by a fluorescent screen. When Röntgen rays fall on it, it is at once seen which thickness of aluminium transmits the same amount as the central silver part. We thus get a scale of hardness of the rays, divided into twelve arbitrary parts. R. S. W.

680. *Röntgen Rays.* **W. Rollins.** (Elect. Rev. N.Y. 39. p. 794, Dec. 28, 1901.)—Röntgen rays, if sent through a condenser of 500 aluminium sheets, are not retarded as they should be if they consisted of flights of charged particles, nor are they deflected on rotating the condenser. For medical work with photographic plates reduce the kathodes, reduce the storage capacity of the secondary coil to a corresponding degree, and send the surges as fast and as regularly as possible; the exposure for a hand is then practically instantaneous. The kathode stream particles come from several sources, the terminals and the residual gases, and the gases must have free circulation so that the kathode stream may have time to recuperate. A. D.

681. *Primary and Secondary Röntgen Radiation.* **H. S. Allen.** (Phil. Mag. 3. pp. 126–128, Jan., 1902.)—The author compares the ionisation produced by the secondary rays with that which would be produced by the primary rays if they continued their path in the original medium, and hence, on the assumption that ionisation is proportional to energy of radiation, deduces the ratio of the energies in the two kinds of radiation. The ionisation produced by the secondary rays was determined by Perrin's method (Comptes Rendus, 124. p. 445) of comparing the rates of leak of two condensers caused by primary radiation alone and by primary and secondary combined. The absorption was determined by Rutherford's method (Phil. Mag. 43. pp. 259–

265, 1897). As yet a complete determination has been made only in the case of sulphuretted hydrogen, which has a large absorption coefficient, with the result that the ratio of the total ionisation due to the secondary radiation from a brass plate, to the total ionisation for the primary radiation, is found to be approximately 1/1900; whence it follows that the total energy of the secondary radiation only amounts to about 1/2000 of that of the primary. G. W. DE T.

682. *Radio-activity.* **H. Becquerel.** (Comptes Rendus, 134. pp. 208–211, Jan. 27, 1902.)—Photographic plates show that the radiations from uranium are wholly deviable by a magnetic field (exposures up to forty-two days); from polonium wholly non-deviable; from radium, mixed. If there be traces of non-deviable radiation from uranium they would require enormous exposures; even with radium they are very penetrating and act very slowly. The deviable radiations from uranium correspond to the least deviable portions of the radiation from radium. In the transformation of white into red phosphorus by the radiations from radium the deviable radiations, identical with kathode rays, are active (sixty days' exposure through glass, which absorbs the non-deviable radiations, and thus leaves the question open whether the non-deviable rays would not also act in the same way); secondary radiations from lead are very active. A. D.

683. *Radio-active Substances.* **P. Curie** and **Mme. S. Curie.** (Comptes Rendus, 134. pp. 85–87, Jan. 13, 1902.)—The authors mention the ideas on the subject which have guided them in their researches. They look upon radio-activity as an *atomic* property of bodies. Each atom of a radio-active substance acts as a constant source of energy. Many varied consequences may be drawn from this hypothesis, which can be submitted to the test of experiment without knowledge of the source whence the radio-active body draws its energy. Experiment points to the conclusion that the radiant activity is rigorously the same whenever the radio-active body is brought back to the same chemical and physical state, and that this activity does not vary with time. Suppositions as to the origin of the energy of radio-activity group themselves round two very general hypotheses: (1) Each radio-active atom possesses in the condition of potential energy the energy which it sets in action; (2) the radio-active atom is a mechanism which draws at each instant from outside of itself the energy which it sends out. On the first hypothesis the potential energy should in the long run become exhausted, but the experience of years has hitherto not indicated any variation. It is conceivable that the radio-active atoms are in course of transformation, but experiment has yielded only negative results. On the second hypothesis radio-active bodies are transformers of energy. This energy might be taken, contrary to the principle of Carnot, from the heat of the surrounding medium, which would experience cooling. It might be furnished from unknown sources—for example, by radiations with which we are not acquainted. J. J. S.

684. *Negative Electrification of Secondary Rays.* **P. Curie** and **G. Sagnac.** (Journ. de Physique, 1. pp. 13–21, Jan., 1902.)—Secondary rays, from heavy metals struck by Röntgen rays, carry negative charges and leave positive charges on the metal; in a high vacuum these charges are independent of the distance traversed, but in presence of air-particles the charges dissociate the neutral electricity of the air into positive and negative particles, just as kathode rays and the deviable radiations from radium do. The exciting Röntgen rays act in producing kathode rays, just as ultra-violet light does

in producing a flux of negative electricity even from an uncharged metal (Righi, Lenard, Meritt, O. M. Stewart), through the production of particularly absorbable kathode rays, traceable only in a high vacuum. Röntgen rays, on the other hand, carry no charges; radium emits uncharged Röntgen rays and charged kathode rays mixed; and it is more and more probable that secondary rays really present a similar mixture. [See also Abstract No. 1644 (1901).] A. D.

685. *Deflection of Becquerel Rays and the Apparent Mass of the Electrons.* **W. Kaufmann.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 2. pp. 143–155, 1901.)—Following up the investigation referred to in Abstract No. 2111 (1901) the author concludes from his experiments that the ratio of the apparent to the real mass of the electrons is of the order one-third for velocities small compared with that of light. F. H. B.

REFERENCES.

686. *Testing of Children's Eyesight.* **J. H. Sutcliffe.** (British Optical Journ. 1. pp. 86–88, Dec., 1901; pp. 116–118, Jan.; and pp. 140–141, Feb., 1902. Paper read before the Manchester Optical Society, Nov. 20, 1901.)—Suggestions as to procedure in preliminary examination, on Burchardt "dot" system, where large numbers of children have to be tested and classified. A. D.

687. *Wave-Number System of Rhodium.* **C. P. Snyder.** (Astrophys. Journ. 14. pp. 179–180, Oct., 1901.)—The paper contains a table of wave-numbers of the arc spectrum of rhodium containing 476 out of a total of 1471. E. C. C. B.

688. *Colouring of Fluorspar by Kathode Rays.* **W. B. v. Czudnochowski.** (Phys. Zeitschr. 3. pp. 82–85, Dec. 1, 1901.)—The paper contains some further observations in continuation of a previous note. [See Abstract No. 383 (1901).] R. S. W.

689. *Duration of Röntgen Ray Emission.* **E. Colardeau.** (Soc. Franç. Phys., Séances, 2. pp. 113–117, 1901.)—The paper contains a fuller account of the experiments referred to in Abstract No. 1073 (1901).

HEAT.

690. *Determination of Vapour Pressure by Evaporation.* **W. Müller-Erzbach.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 519–536, May and June, 1901.)—The method was explained in Abstract No. 2425 (1900). It proves very convenient and reliable, provided the temperature be kept steady and be not near the boiling-point. According to Stefan, the diameters of the tubes from which the liquid is evaporated should not exceed the limits 0·6 to 6 mm. The author obtained good results with tubes up to 23 mm., but a beaker 46 mm. in diameter, lost three times its calculated amount of water vapour. From comparative determinations of the amounts of water and chloroform, evaporated at the same temperature, satisfactory values for the vapour pressure of chloroform were also derived more easily than by the manometric method. But solid substances—methyl oxalate, naphthalene, and the carbon chloride C_2Cl_6—yielded less concordant results, because they give off vapours of less than normal pressure; this circumstance, however, affects manometric methods likewise. H. B.

691. *Graded Condensation in Benzine Vapour.* **C. Barus.** (Science, 15. pp. 175–178, Jan. 31, 1902.)—The author describes the results of experiments on condensation in benzine, which, contrary to his expectation, confirm the nuclear theory. By adiabatic cooling on partial exhaustion, cloudy condensation was as densely produced in benzine vapour as in water vapour with phosphorus and other nuclei, and when the receiver was illuminated with white light diverging from an external point, axial colours were obtained running into higher orders than with water vapour. No doubt, owing to the lower latent heat of benzine, the drops formed were regularly larger. In the absence of nucleation either no marked condensation occurred or rain like a fine mist fell. In other experiments nearly parallel light was used, the sun's image being the coronal centre, and again an incandescent mantle seen through a small hole in a metallic screen by an eye looking centrally through the receiver. The coronas were fleeting, with a tendency to depart from the normal annular character into sharply defined horizontal strata; the speed of descent of the coloured bands was noticeable, as was their rise upward, like fog from a lake, on exhaustion. Owing to its smaller latent heat of evaporation the benzine drops are larger, and therefore the subsidence of the *loaded* nuclei more rapid than for water. Regarding the loaded nuclei as mechanical particles, the largest will eventually be in the lowest strata, and on increasing exhaustion, condensation takes place first at the bottom, since the smallest nuclei correspond to greatest vapour pressure, or difficulty in condensation, and the largest nuclei, being first loaded with condensed liquid and parting with it last, have had the longest time to fall. Similar experiments with benzol lead to the additional result that nuclei are produced by the liquid itself *spontaneously* in the dark. W. E. T.

692. *Measurement of High-pressure Explosions.* **J. E. Petavel.** (Manchester Lit. and Phil. Soc., Mem. 46. 2. pp. 1–16, Feb. 10, 1902.)—An exceedingly dead-beat sensitive high-pressure gauge, the movements in which are arranged to extend over not more than about $\frac{1}{300}$ inch, but are capable of being

continuously recorded on a large scale by a reflexion method, is here described. It is being applied in the investigation of the variations of pressure that occur during and after explosions of gaseous mixtures, in illustration of which the pressure curves for the explosion of two mixtures of air and coal-gas are given and explained. They indicate that (1) the time required for the maximum pressure to be reached, viz., 0·058 sec., when the initial pressure is about 76 atmospheres, is much about what it is for the same mixture under 1 atmosphere; (2) the ratio of the maximum to the initial pressure increases with the latter, being about 8·5 for 76 atmospheres initially, and about 7 for 1 atmosphere; (3) the rate of cooling of the exploded mixture greatly decreases with increase of the pressure.

With these two mixtures the rate of rise of pressure is small for about 0·05 sec. and then becomes about nine times as great, such alteration of curvature not occurring with less explosive mixtures; the change seems to occur when the mixture is at a mean temperature about equal to that at which spontaneous ignition would take place. R. E. B.

693. *Cooling of Closed Rooms.* **G. Recknagel.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1801-1809, Dec. 21, 1901.)—This is an application of Fourier's theory and method to a closed empty room with walls that are impervious to heat except on one side, where it is separated from the outer air, at constant temperature A, by a homogeneous and windowless wall, of surface F, thickness δ (small in comparison with F), density s, specific heat w, and conductivity λ, the enclosed air being perfectly still and at the same temperature J throughout.

If the temperatures throughout are stationary, those of the faces of the wall being $\mathfrak{T}_i$ and $\mathfrak{T}_a$, and h_1, h_2 are the external conductivities of the wall inwards and outwards (which may differ by reason of wind, &c.), the flow of heat is given by—

$$h_1(\mathrm{J}-\mathfrak{T}_i)=\lambda(\mathfrak{T}_i-\mathfrak{T}_a)/\delta=h_2(\mathfrak{T}_a-\mathrm{A}),$$

so that—

$$\mathfrak{T}_i-\mathrm{A}=(\mathrm{J}-\mathrm{A})(1-p/h_1),\qquad \mathfrak{T}_a-\mathrm{A}=(\mathrm{J}-\mathrm{A})p/h_2,$$

where p is the *transmission-coefficient* of the wall which is given by—

$$1/p=1/h_1+\delta/\lambda+1/h_2;$$

and the temperature U at any point in the wall distant x from the inner face is given by—

$$\mathrm{U}-\mathrm{A}=(\mathrm{J}-\mathrm{A})(1-p/h_1-px/\lambda).$$

If the temperatures are variable, then—

$$\partial\mathrm{U}/\partial z=\kappa\partial^2\mathrm{U}/\partial x^2,$$

where z denotes time and $\kappa\equiv\lambda/sw$: a simple integral is—

$$\mathrm{U}-\mathrm{A}=\alpha(\cos mx+\beta\sin mx)e^{-\kappa m^2 z},$$

where α, β, m are constants. At the outer face we must have—

$$\mathrm{F}h_2(\mathfrak{T}_a-\mathrm{A})=-\mathrm{F}\lambda[\partial\mathrm{U}/\partial x]_{x=\delta}\text{ and }\mathfrak{T}_a=[\mathrm{U}]_{x=\delta}$$

whence—

$$\tan m\delta=(\beta m+p_2)/(m-\beta p_2),$$

where $p_2 \equiv h_2/\lambda$, so that there is an infinite number of possible values of m, and thus, if $e_n \equiv exp(-\kappa m_n^2 z)$, the general solution is of the form—

$$U - A = \Sigma . a_n e_n (\cos m_n x + \beta_n \sin m_n x).$$

Also at the inner face we must have—

$$Fh_1(J - \mathfrak{T}_i) = -F\lambda[\partial U/\partial x]_{x=0} \text{ and } \mathfrak{T}_i = [U]_{x=0},$$

whence—

$$J - A = \Sigma . a_n e_n (1 - \beta_n m_n/p_1),$$

where $p_1 \equiv h_1/\lambda$. But if L is the mass of the inner air and c its specific heat, the flow of heat is also $-Lc\partial J/\partial z$, or—

$$\partial J/\partial z = (F\lambda/Lc)\Sigma . a_n e_n \beta_n m_n ;$$

and $J = A$ when $z = \infty$, so that—

$$J - A = -\sigma\Sigma . a_n e_n \beta_n/m_n,$$

where $\sigma \equiv Fs\varpi/Lc$. Thus—

$$1 - \beta_n m_n/p_1 = -\sigma\beta_n/m_n \quad \text{or} \quad \beta_n = p_1 m_n/(m_n^2 - \sigma p_1),$$

so that the equation giving the values of m is—

$$m \tan m\delta = \{(p_1 + p_2)m^2 - \sigma p_1 p_2\} / \{m^2 - p_1(\sigma + p_2)\}.$$

The values of the coefficients $a_1, \ldots$ are obtained from the initial conditions by a method analogous to that of Fourier. Initially we have—

$$U_0 - A = \Sigma . a_n (\cos m_n x + \beta_n \sin m_n x).$$

Now we easily prove that—

$$\int_0^\delta (\cos m_n x + \beta_n \sin m_n x)(\cos m_r x + \beta_r \sin m_r x) dx$$

$$= -\sigma\beta_n\beta_r/m_n m_r, \text{ if } n \text{ is unequal to } r, \text{ and}$$

$$= \sec^2\phi_r \{m_r\delta + \sin m_r\delta \cos(m_r\delta - 2\phi_r)\}/2m_r \equiv B_r, \text{ if } n = r,$$

where $\phi \equiv \tan^{-1}\beta$. Thus—

$$\Phi_r \equiv \int_0^\delta (U_0 - A)(\cos m_r x + \beta_r \sin m_r x) dx$$

$$= -\sigma(\beta_r/m_r)(\Sigma . a_n\beta_n/m_n - a_r\beta_r/m_r) + B_r a_r$$

$$= (\beta_r/m_r)(J_0 - A + \sigma a_r\beta_r/m_r) + B_r a_r,$$

where J_0 is the initial temperature of the enclosed air, so that—

$$a_r = \{\Phi_r - (J_0 - A)\beta_r/m_r\} / \{B_r + \sigma(\beta_r/m_r)^2\}.$$

The problem is thus completely solved. The loss of heat in time z is—

$$V_z \equiv Fh_2 \int_0^z (\mathfrak{T}_a - A) dz$$

$$= (Fh_2/\kappa)\Sigma . (a_n/m_n^2)(\cos m_n\delta + \beta_n \sin m_n\delta)(1 - e_n),$$

the constant part of which obviously denotes the excess of the heat in the

wall and enclosed air initially over what they would have at A, and the remainder denotes the similar excess at the time z.

If the initial state is that of stationary temperatures, then—

$$U_0 - A = (J_0 - A)(1 - p/h_1 - px/\lambda),$$

so that—

$$\Phi_r = (J_0 - A)\{p/\lambda + (1 - p/h_1)\beta_r m_r\}/m_r^2,$$

and thus—

$$\Phi_r - (J_0 - A)\beta_r/m_r = -(\sigma p/\lambda)(J_0 - A)\beta_r/m_r^3.$$

Consequently $(U - A)/(J_0 - A)$ is independent of the absolute values of the temperatures.

This theory is applied to a room of volume 100 c.m., with a brick wall for which $F = 20$ sq.m., $\delta = \frac{1}{4}$ m., $s = 1800$, $w = 0{\cdot}2$, $\lambda = 0{\cdot}7$, $h_1 = h_2 = 6$ Cal. per hour (which assumes that there is no wind outside, otherwise h_2 might amount to 36), so that $p = 42/29$, $p_1 = p_2 = 60/7$, $\kappa = 1/514$. [The author takes $\sigma = 250$, and therefore apparently assumes for c the isopiestic value 0·2389 in place of the isometric one, since, for the dimensions taken, $L = 120{\cdot}5$ at 1 atmosphere and 20°.] Then—

$$\tan \tfrac{1}{4}m = 120(7m^2 - 7500)/(49m^2 - 108600)$$

$$\beta = 60m/(7m^2 - 15000),$$

which give the following values in order :—

Order.	m	$m\delta$	β	ϕ	$e^{-\kappa m^2}$	$a/(J_0 - A)$
1	4·338	62° 9′	−0·01751	− 1° 0′	0·9640	0·63894
2	14·45	180° + 27 0	−0·06407	− 3 40	0·6661	0·07651
3	25·82	360 + 9 50	−0·1499	− 8 32	0·2735	0·03235
4	37·04	540 − 9 20	−0·4120	− 22 23	0·0694	0·02395
5	45·48	720 − 68 32	−5·243	− 79 12	0·0179	0·00407
6	53·24	720 + 42 34	0·6636	33 34	0·00404	−0·01000
7	64·42	900 + 22 48	0·2751	15 23	0·000241	−0·00374

The values of a in the last column are calculated on the assumption of the temperatures being initially stationary. If $J_0 = 20°$ and $A = -20°$, the following distributions of temperature occur at the times specified :—

Time in hours.	0	1	2	10
Enclosed air	20	7·82	5·6	− 2·1
Inner face of wall ...	10·35	7·10	5·2	− 2·2
At 0·2 of its thickness	6·2	5·4	4·1	− 2·7
„ 0·4 „ „ ...	2·1	1·9	0·9	− 4·0
„ 0·7 „ „ ...	− 4·1	− 4·1	− 4·2	− 7·4
Outer face of wall ...	− 10·35	− 10·35	− 10·53	− 12·24
Outer air	− 20	− 20	− 20	− 20

These show the slow cooling of the outer face of the wall and the initially very rapid cooling of the enclosed air in comparison with that of the inner face of the wall.

If the maximum amount of heat which the enclosed air can lose, viz., $Lc(J_0 - A)$, is taken as unit, the total amount there is initially to lose is

$0{\cdot}01502\sigma p_2 = 32{\cdot}19$, of which the air possesses 1 and the wall 31·19; after 10 hours the amount there is to lose is $0{\cdot}01061\sigma p_2 = 22{\cdot}74$, of which the air has $17{\cdot}9/40 = 0{\cdot}45$ and the wall 22·29. Thus in 10 hours the loss is $9{\cdot}45/32{\cdot}19 = 0{\cdot}294$ of the whole, and of this loss the air has supplied only about one-seventeenth. Further, during this period the average rate of loss is 0·945 per hour, which is but little less than at the start, viz., 1·006. R. E. B.

694. *Heat of Inversion of Saccharose.* **P. Petit.** (Comptes Rendus, 134. pp. 111–112, Jan. 13, 1902.)—The author gives results of measurements of the heat evolution taking place when saccharose undergoes inversion. The experiments were made by means of a closed calorimeter surrounded by a double envelope of vapour from a constant boiling-point liquid. The mean values obtained for the heat evolved when 1 grm.-mol. of saccharose, dissolved in 140 grm.-mols. of water, is inverted are: (1) 2·639 cals. at 58·5° and (2) 2·675 cals. at 63°. T. H. P.

695. *Man as a Heat-Engine.* **K. Schreber.** (Phys. Zeitschr. 3. pp. 107–109, Dec. 15, 1901.)—If we take the interior temperature at 37° and the exterior as 17° (the average temperature of the air), we find the efficiency would be $100 \times (37 - 17) \div (37 + 273) = 6{\cdot}5$ per cent. Rühlmann gives an estimate up to 24 per cent., but this is vitiated by irregularities of effort which may mount as high as 1 h.p., though the average over a long period is less than 0·1 h.p., and these irregularities do not at once call for similar variations in food. Observations must therefore extend over considerable periods. Ržiha gives the datum 127,000 kg.m. as a man's mean daily work over such a period. Grasmann gives the heating value of a man's food, per 100 kg. body weight, as 3,400 Ca during rest, 5,400 during moderate, and 7,600 during hard work. For a man of 60 kg. weight these data would give 6·5 per cent. efficiency during hard work. But 60 kg. is too little; say 70 kg.; then the efficiency is 5·6 per cent. Ržiha's hardest day's work was 141,000 kg.m. Taking this datum we have for a man 60 kg. weight an efficiency of 6·2 per cent. If instead of 37°, as above, we take 39°, the temperature of the blood, the 6·5 per cent. above is increased to 7·1 per cent. The estimation of the inferior temperature is, however, of more importance, but is difficult; if we take the temperature of the skin (32°·3 to 35°·8 and 31° on the face), our theoretical efficiency would be only 2·6 per cent. The work of the involuntary muscles may be neglected (the heart 3,000 m.kg. a day). With a theoretical efficiency of only 2·6 per cent., man as a heat-engine would not obey Carnot's law. He should probably be likened not to a heat-engine, but to an electric station with a large accumulator capacity; but it would be difficult, for any short-period test, to ascertain what the reserve of energy was at the beginning and at the end of the test. Still some attempt should be made in that direction. A. D.

696. *Theory of Saturation State.* **C. Dieterici.** (Ann. d. Physik, 6. 4. pp. 861–869, Dec., 1901.)—A deduction is given of the equations—

$$\lambda = T(v_2 - v_1,)dp_s/dT \text{ and } \lambda/T - d\lambda/dT = c_s - h_s$$

where λ is the latent heat of evaporation, p_s the saturation pressure, c_s and h_s the specific heats of the liquid and its vapour, which depends on the possibility of bringing a liquid under saturation pressure at a given temperature to the vapour state at the same pressure and temperature by two different paths—

(1) isothermally, whilst the pressure remains constant, (2) along the saturation curve, raising the temperature to the critical point and then cooling again to the given temperature. Also, from the consideration of the theoretical path suggested by van der Waals, which is both isothermal and continuous, the author deduces the equation $\int_{v_1}^{v_2}(\partial p/\partial T)dv = (v_2 - v_1)dp_s/dT$. Calculating, for various substances, the temperature for which the external work done in isothermal evaporation is a maximum, he finds that the critical temperature bears to it the constant ratio 1·30 to 1. W. E. T.

697. *Law of Constancy of Quantity of Heat.* **J. P. Kuenen.** (Archives Néerlandaises, 6. pp. 39–46, 1901.)—The conception, quantity of heat, was originally based on the results of the law of mixing, which may in the simplest case be expressed by the equation $\Sigma mc(t - T) = 0$, where m is the mass, c the specific heat, and t the temperature of any constituent of the *mixture*, T being the common final temperature. When change of state occurs the theory may be represented by the equation $\Sigma mc(t - T) + \Sigma Ml = 0$, where M is the mass of any constituent transformed, and l the latent heat, so called to indicate its independence of temperature. These equations do not strictly express the case, since specific heat varies with the temperature. The questions which present themselves are therefore: (1) What is the proper relation between the masses and temperatures? (2) Can this relation be interpreted so as to express the constancy of a quantity which can be defined as quantity of heat? (3) On what experimental facts is this relation based? The following experimental laws, if fully substantiated, would suffice for the determination of (1): (*a*) The final temperature of mixture, where no transformation of energy occurs, is independent of the order of mixture, and may be expressed in the form $T = F(m_1m_2, \ldots t_1,t_2 \ldots)$; (*b*) If the masses are altered in the same proportion, the temperatures being the same, T will be unaltered: hence $T = \text{Hom}^0.(m_1, m_2, \ldots t_1,t_2, \ldots)$, which may be transformed into $\text{Hom}^n.(m_1,m_2, \ldots t_1,t_2 \ldots T) = 0$. Now take substances 1, 2, 3, 4, choosing values of m and t such that the mixtures 1,2; 2,3; 1,4, may have the same final temperature. Then the mixture 3,4 should have the same final temperature, or its characteristic equation should be the consequence of that for the other three mixtures. The third law (*c*) may therefore be stated thus: If of four substances of given mass and temperature 1 and 3 produce the same change in 2, while 2 and 4 produce the same change in 1, then 2 and 4 produce the same change in 3. These laws enable the character of the function to be determined, and lead to the equation $\Sigma_k m_k f_k(t_k - T) = 0$, as the expression for the law of mixture. Equation (3,4,) will then follow from the other three, viz.: $(1,4,) - (1,2,) + (2,3,) \equiv (3,4,)$. The conception of quantity of heat may then be introduced by defining $f_k(t_k - T)$ as the quantity of heat given off by unit mass of the substance in cooling from t_k to T, and the typical equation obtained expresses the law that in mixing bodies of different temperatures the total quantity of heat remains constant, which thus appears to be quite independent of the approximate laws of mixing, on which it was originally based, but is by no means a self-evident law. Whether it is correct can only be settled by experiments, and those suggested above appear to the author to be the simplest for the purpose, although others might serve equally well. G. W. DE T.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

698. *Ether, Matter, and Electricity.* **N. E. Gilbert.** (Terrestrial Magnetism, 6. pp. 147–166, Dec., 1901.)—This paper is based on H. A. Rowland's ideas. The existence of permanent magnetism shows that any retardation of rotary or vortical motion, such as is held to explain magnetism, due to any kind of resistance, must be very slight. In the case of an electromagnet, any energy used in overcoming such resistance, if it exists, must be derived from the exciting current, and must manifest itself through an apparently greater resistance of coiled wire when a magnetic field is being maintained than when it is not; but the measurements show a resistance slightly *smaller* (by 1 in 1,200,000) in the former case. This tends to show that there is no drag between ether and matter: if there were, there ought to be a current generated in a wire wound on the periphery of a wheel in such a way that it would move in the direction of its length when the wheel was rotated, and further, this current would completely explain the earth's magnetism; but the result of an elaborate research is on the whole purely negative, no such current being found or, if any, not determinate in direction, and far too small to correspond with theory. A. D.

699. *Electric Field of an Ellipsoidal Conductor.* **G. Jäger.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 449–453, May and June, 1901.)—Let the ellipsoid be represented by—

$$\frac{x^2}{a_0^2} + \frac{y^2}{b_0^2} + \frac{z^2}{c_0^2} = 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Then it is shown that the equipotential surfaces are the confocal ellipsoids—

$$\frac{x^2}{a_0^2 + \lambda} + \frac{y^2}{b_0^2 + \lambda} + \frac{z^2}{c_0^2 + \lambda} = 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The potential of any point is expressed in terms of the parameter λ of the surface on which it lies, and the charge Q on the conductor, by the equation—

$$V_\lambda = \frac{Q}{2} \int_\lambda^\infty \frac{d\lambda}{\sqrt{(a_0^2 + \lambda)(b_0^2 + \lambda)(c_0^2 + \lambda)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

E. H. B.

700. *Electrostriction.* **J. S. Shearer.** (Amer. Phys. Soc., Bull. 2. pp. 27–28, 1901.)—In order to test whether the electric field causes volume changes, a refractometer method was used on, among other things, long thin glass tubes silvered outside and in. The potential was gradually raised until the tube punctured, the tubes being 0·8 to 2·0 mm. thick. No movement exceeding $\frac{3}{8}$ of a band width was ever observed, and the author concludes that if electrostriction actually exists, its magnitude is much less than has been generally supposed. [See also Abstract No. 2440 (1900).] G. E. A.

701. *Daily Periodic Variation in Atmospheric Electricity.* **F. Exner.** (Akad. Wiss. Wien, Sitz. Ber. **110.** 2a. pp. 371–386, April, 1901.)—The measurements made at different places on the earth's surface show sometimes a single period and sometimes a double period in the day in the changes of atmospheric potential, while others again show a practically constant potential during the twenty-four hours. The single period has a flat maximum covering all the hours of the day, with a correspondingly flat minimum for the night. The double period has maxima about 8 a.m. and 8 p.m., separated by a strong depression of potential about midday. In some places the type changes with the time of year, giving the first type in winter and the second in summer. The author compares the measurements for many widely separated places, and concludes that the normal variation of atmospheric potential is given by a single period, and that the double period, which occasionally occurs, arises from a disturbance of the normal single period, resulting in a midday lowering of potential. This depression occurs especially in dry districts (or in summer), and appears to be the result of a negatively charged layer gathering at noon over the places of observation. This layer, which does not appear to extend beyond some hundred metres in height, also manifests itself by a strong absorption of the ultra-violet solar rays. W. C. H.

DISCHARGE AND OSCILLATIONS.

702. *Dispersion of Electricity in Air.* **W. Loevy.** (Phys. Zeitschr. 3. pp. 106–107, Dec. 15, 1901.)—Strong wind favours dispersion of charge; so do rise of temperature, of moisture, and of atmospheric pressure. The coefficient of dispersion falls off when the voltage rises to, say, 500; and it is at a maximum at 8 a.m. and 8 p.m. Sunlight accelerates the dispersion of negative electricity; and during rain a unipolar dispersion of positive charge was found. A. D.

703. *Ionisation of Air.* **H. Ebert.** (Phys. Zeitschr. 2. pp. 662–664, Aug. 17, 1901.)—Some account of this investigation has already been given in Abstract No. 2146 (1901) [see also Abstracts Nos. 629, 849, and 2144 (1901)]. The ionisation is great in sunny weather; when dust or smoke are present, or the relative humidity is high, it becomes less. Hence these cannot account for the loss of charge of an insulated body exposed to the air. Its absolute amount is small, on the average as much as would be produced by the ionisation of $\frac{1}{3} \times 10^{-14}$ grm. or $\frac{1}{3} \times 10^{-10}$ c.c. of hydrogen per c.m. If the 1–10,000 billionth part of the oxygen contained with air were dissociated, the ionic charges of this fraction would suffice to account for the effects observed. D. E. J.

704. *Discharge from a Tesla Pole.* **E. Knoblauch.** (Ann. d. Physik, 6. 2. pp. 353–372, Oct., 1901.)—High-frequency currents discharged from a fine point in air impart a positive charge to an insulated metallic plate near at hand, whereas at greater distances the plate becomes negatively charged [see Abstract No. 844 (1901)]. According to Himstedt [Ann. d. Physik, 52. p. 473, 1894; and Abstract No. 1708 (1899)], both negative and positive electricity are discharged from a Tesla pole, but the negative electricity is propagated more rapidly than the positive; at short distances the positive electricity is in excess, whereas at great distances the negative alone reaches the plate. The author has measured the potentials of the plate and point

(Tesla pole) at various distances from each other, and has examined the circumstances under which the change of sign takes place. This change can easily be demonstrated by an electrometer, or even by a Bohnenberger electroscope. The discharge is started at a distance of about 6 cm. and the point gradually brought nearer to the plate; at 4–5 cm. distance the needle is violently disturbed and then goes over to the positive side. With plates 1 to 18 cm. in diameter this was found to occur at distances greater than 4–4·2 cm. The point of inversion can, however, be removed further by using a zinc plate of 18 cm. diameter with a circular opening of 2–8 cm. cut out of it: for the negative discharge appears to surround the positive charge like a mantle. If the opening is greater than 8 cm. diameter no positive charge can be given to the plate. The behaviour of the discharge can also be studied by means of Lichtenberg figures, which clearly show a negative ring surrounding a positive disc. These statements, however, only apply when the discharge is of the nature of a radiation from the point; the direct spark-discharge between point and plate is an oscillating discharge. D. E. J.

705. *Counter E.M.F. of the Arc.* **H. J. Hotchkiss.** (Amer. Phys. Soc., Bull. 2. pp. 19–22, 1901.)—The author's experiments lead to the conclusions, (1) that if there is a back e.m.f. dying out in one ten-thousandth of a second, it does not have an average value for that time as large as two-thirds of a volt; (2) at the instant the impressed e.m.f. is removed the back e.m.f. is probably very nearly zero, and increasing instead of decreasing; (3) after the first ten-thousandth of a second there is a back e.m.f. which rises rapidly at first, then more slowly, to a maximum of less than 1 volt in about one-fiftieth of a second. W. C. H.

706. *Deflection of the Magnetic Needle Produced by Kathode Rays.* **J. v. Geitler.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 358–364, April, 1901. From the Physik. Inst. der K.K. deutschen Universität Prag.)—From experiments described in Wiedemann's Annalen, 19, p. 798, and in his collected works, vol. i., Hertz was led to conclude that the kathode rays have no effect on a magnetic needle. In view of the fact that the rays are affected by a magnetic field, the author was led to seek for a possible source of error in Hertz's experiments. He supposes that the charges produced where the kathode rays meet the inner surface of the tube create a backward flow of tubular form, which backward current neutralises the effect of the rays on a needle situated outside of the backward tubular flow. He describes experiments to test this view, in which the magnetic needle is placed *inside* of the vacuum tube in which the rays are produced, in such a position that the backward tubular current surrounds the needle, and is therefore without effect upon it. He finds that the kathode rays affect the needle in the same way as a positive current flowing in the path of the rays but in the opposite direction. The results are qualitative only. W. S.

707. *Visible and Invisible Kathode Rays.* **E. Goldstein.** (Deutsch. Phys. Gesell., Verh. 3. 15. pp. 192–203, 1901.)—Various observers have found that if a plate kathode be used, which reaches to the walls of the tube, then, as the pressure is lowered, the luminous part of the kathode bundle of rays retreats to the centre of the disc. The author shows that this is due to the walls of the tube near the kathode acting as an anode, and that in this state there is a stream of invisible kathode rays proceeding from the outer portions of the

720. *Hall's Effect and its Analogues.* **E. van Everdingen, Jr.** (Archives Néerlandaises, 4. pp. 371–476, 1901.)—A full summary is given of the work done at Leyden by A. Lebret and the author since 1895, together with a general historical survey of the subject, the matters considered being: Hall's effect, dissymmetry of Hall's effect, increase of resistance in a magnetic field, difference of temperature between two secondary electrodes in a magnetic field, transversal difference of temperature across a heat-flow in a magnetic field, diminution of heat conductivity in a magnetic field, difference of potential across a heat-flow in a magnetic field, difference of potential along a heat-flow in a magnetic field. Lebret's compensation method of measuring Hall's effect, to eliminate thermoelectric and other perturbations; discussion of the possible sources of error. Dissymmetry is explained as due to a difference in the increase of resistance in two principal directions, which directions are related to the mean trend of the crystallographic axes of the metal (bismuth). An investigation is given, with mathematical developments, of the distribution of current in a circular plate of bismuth, placed in a magnetic field, and calculation of the resistances in the principal directions. The mean Hall effect is not the same when an axis of symmetry lies directly between the electrodes and when it does not; this was traced to the state of aggregation of the bismuth. With very thin electrolytically deposited bismuth the bismuth is so irregularly deposited that outside a magnetic field the metal may be considered isotropic; but in a field not at right-angles to the plate it becomes not so; in a field at right-angles to such a plate the isotropism would persist, and there could be no true dissymmetry, only an apparent dissymmetry when the secondary electrodes are not equipotential. Any appreciable thickness of such a film will introduce another cause of apparent dissymmetry, the increase of resistance along the lines of force. A plate cut from a crystal at right-angles to the principal axis would be perfectly isotropic parallel to its faces, and would act as in the last-mentioned case; if cut parallel to that axis there would be anisotropism and dissymmetry in Hall's effect. In the ordinary bismuth plate made by casting we have crystals irregularly soldered together, and there is then no determinate Hall coefficient. [See also Abstract No. 2156 (1901).] A. D.

721. *Influence of Tempering on the Decay of Magnetic Moment.* **I. Klemenčič.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 415–420, April, 1901. From the Physik. Inst. der K.K. Universität in Innsbruck.)—Following his former researches [see Abstracts Nos. 139, 1131, and 1333 (1901)] the author takes rods of silver steel, tempers them alike, then magnetises the first rod one minute after tempering, the next rod two minutes after tempering, and so on, up to intervals of sixty minutes. He watches for every bar the subsequent loss in magnetic moment. The tables show that the retentivity increases with increase of the interval mentioned. P. E. S.

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freshly annealed specimen is less as the permeability is greater. The magnetometric method is used throughout. Tables of observations on crude and refined iron are given. [See also preceding Abstract.]
P. E. S.

723. *New Magnetographs.* **W. Watson.** (Terrestrial Magnetism, 6. pp. 187–192, Dec., 1901.)—The paper describes a set of magnetographs designed by the author for the magnetic survey of India, similar to his instruments for the determination of the disturbances of the three magnetic elements by electric railways, which are specially adapted for ready working with poor accommodation. The vertical component is not recorded in the Indian survey, but the respective instruments are also mentioned. The horizontal intensity instrument has a magnet system of nine magnets, cemented in an aluminium centre-piece which hooks on to the suspension and carries the movable mirror; the movable portion weighs 6·5 grm. The suspension is by quartz fibre. As that fibre becomes stiffer at higher temperatures, a fine phosphor-bronze strip is used for suspension in the declination instrument, and the temperature coefficient is thus reduced. But the author finds that there is a creep of the spot due to the fatigue of the metal, and he would therefore prefer quartz suspension when the magnetograph can be protected from large and rapid temperature changes, retaining the phosphor-bronze for short-period records. The temperature coefficient can also be adjusted by varying the number and nearness of the magnets. H. B.

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725. *Canal Rays in Vacuum Tubes.* **E. Goldstein.** (Deutsch. Phys. Gesell., Verh. 3. 15. pp. 204–212, 1901.)—A critical *résumé* of our knowledge of these rays.
R. S. W.

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D. E. J.

728. *Electric Conduction in Gases.* **J. Stark.** (Phys. Zeitschr. 2. pp. 664–666, Aug. 17, 1901).—A criticism of J. J. Thomson's theory of electric conduction in gases. [See Abstract No. 1156 (1899).] D. E. J.

715. *Wehnelt Interrupter.* **A. Lampa.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 891–906, July, 1901. From the Physik. Cabinet der K.K. Universität in Wien.)—This is an extension of the article referred to in Abstract No. 870 (1901) of the author's paper. In order to find an explanation of the different effects observed when the small electrode is positive and negative, respectively, a mathematical investigation is made of a circuit consisting of a battery, a self-inductive resistance, and a Wehnelt interrupter, the interrupter having a condenser connected between its terminals. The spark-gap resistance presents great difficulty, as Ohm's law does not apply. For the author's purpose it is therefore replaced by an inductionless resistance which is supposed to be bridged across the condenser at the moment that the potential there reaches its sparking value. The conditions are found which determine whether, in such a circuit, the current at discharge shall be periodic or aperiodic, but owing to the difficulty of assigning specific values for the initial current and potential, the analysis can scarcely be applied to give quantitative results. It seems probable that the oscillatory condition of discharge at the place of interruption is to be expected when the separation between the electrode and the electrolyte is sudden. This explosive separation, and oscillatory character of corresponding discharge, the author has observed by means of a rotating mirror when the active electrode is negative. In normal circumstances, *i.e.*, with active electrode positive, the discharge is not oscillatory. By diminishing the size of the active electrode, the current remaining constant, the current density at the electrode surface is increased, and the discharge is rendered more abrupt. Using an electrolyte of dilute sulphuric acid, when the Pt active electrode is positive, there is a red glow, and a hydrogen spectrum. If, however, the active electrode is negative, the spectrum shows platinum as well as hydrogen to be present in the bubbles. Regarding now the active positive electrode as a "point," and the limiting surface, the bubble of electrolyte immediately surrounding it, as a discharging "plate," the author compares the action to the disruptive discharge mentioned by Faraday (Experimental Researches, vol. i. series xiii. § 1480 *et seq.*): Between a large ball and a small ball far longer sparks are obtained when the small ball is positive than when it is negative. In the last part of the paper the author endeavours to bring this into conformity with his own observation that the discharge in a Wehnelt interrupter is oscillatory when the active electrode is negative. R. A.

716. *Current Interrupter.* **D. Turner.** (Roentgen Ray, Archives, 6. pp. 4–5, Aug., 1901.)—The apparatus is intended as an interrupter for an induction coil, especially for Röntgen-ray work. It is a mechanical device, the contact pieces consisting of brass rollers held together by a spring. The rollers are actuated by a cam, which serves the double purpose of rotating them and of bringing them into and out of contact. When this interrupter is used in air the secondary discharges are feeble. A much better result is obtained when they are immersed in water. But by far the best effect is obtained when they are plunged into petroleum. As compared with a mercurial interrupter it is claimed that the metallic contact is more perfect; the break is more complete and sudden, owing to there being no oscillating liquid conductor; and further, the action is more rapid, the frequency, if necessary, approaching to that of the Wehnelt interrupter. For Röntgen-ray work, by the use of this mechanical arrangement, very much sharper photographs are said to be obtained, because the exposures are shorter, and consequently the secondary radiations are unable to blur the plate, and the shadows of soft parts are more evident. R. A.

717. *Current Rectifier for Röntgen Ray Work.* **R. S. Wright.** (Roentgen Ray, Archives, 6. pp. 6–7, Aug., 1901.)—The method consists in passing the alternating current unrectified through the primary of the coil, and rectifying the secondary current by providing two paths for the secondary discharge, each containing a spark-gap with ball-and-point terminals respectively, so arranged as to produce rectification by means of their selective action. [This selective action is due to the fact, noticed by Faraday (Experimental Researches, vol. i. p. 473), that between a small ball and a large one far longer sparks are obtained when the small ball is positive than when it is negative.] By placing a focus-tube in one of these paths a uni-directional discharge was obtained, the opposite current passing through the alternative gap. The resistance of the focus-tube may be balanced by arranging a longer spark-gap in the other branch, or by placing a focus-tube in each path. Tesla currents can be rectified by a similar device. For Röntgen-ray work, however, the ball-and-point arrangement did not at first give good results; "the alternations of the current itself not being sudden enough to produce a good secondary discharge." After using several forms of break, the authors fitted a Mackenzie Davidson mercury break with a motor to run synchronously, and obtained nearly perfect working. R. A.

718. *Coherer.* **F. L. Odenbach.** (West. Electn. 29. pp. 349–350, Nov. 30, 1901.)—In this paper the author describes a form of coherer which he has employed in a circuit arranged as for wireless telegraphy, to record on a revolving drum the time and duration of atmospheric electrical disturbances due to storms. On a light piece of cherrywood, 2 inches wide, 3 inches long, and $\frac{1}{8}$ inch thick, the author places four small brass posts. Over each pair he stretches German silver or fine steel wires parallel to each other, letting them sag slightly. One pair is joined to one end of the relay circuit, the other pair to the other end. Across the gap, *i.e.*, from one span of wire to the other, he places a piece of graphite, long enough to project over the wires on each side. A. W. Faber's Siberian leads for artists' pencils H. No. 5900 were found to give the most perfect results. This form of coherer is said to be extremely sensitive. R. A.

ALTERNATING CURRENTS AND MAGNETISM.

719. *Geometrical Loci in Clock Diagrams.* **M. Schenkel.** (Elektrotechn. Zeitschr. 22. pp. 1043–1045, Dec. 19, 1901.)—In the study of most forms of alternating-current apparatus, when the connection between the various quantities has been graphically exhibited by a clock diagram, it is of great importance to know how a change in one of the quantities affects the others, *i.e.*, what curves are traced out by the extremities of the vectors when the load varies. Such a curve or locus may be determined by a point-by-point method, using a geometrical construction; but this method is very laborious. It is found that in many cases the locus is a circle or a straight line. Having stated the fundamental theorems regarding the addition, subtraction, multiplication, and division of vectors, the author points out that in many important problems the ratio ρ of two vector quantities may be expressed in terms of a variable vector x of *constant direction* by the vector equation—$\rho = (a + xb)/(c + xd)$, and shows that if one of the vector quantities remains constant, the extremity of the other traces out a circle. This circle passes through the origin if $a = 0$; it becomes a straight line if $c = 0$, and shrinks into a point if $a = c = 0$. The author illustrates this method by applying it to a boosting transformer. A. H.

720. *Hall's Effect and its Analogues.* **E. van Everdingen, Jr.** (Archives Néerlandaises, 4. pp. 371-476, 1901.)—A full summary is given of the work done at Leyden by A. Lebret and the author since 1895, together with a general historical survey of the subject, the matters considered being: Hall's effect, dissymmetry of Hall's effect, increase of resistance in a magnetic field, difference of temperature between two secondary electrodes in a magnetic field, transversal difference of temperature across a heat-flow in a magnetic field, diminution of heat conductivity in a magnetic field, difference of potential across a heat-flow in a magnetic field, difference of potential along a heat-flow in a magnetic field. Lebret's compensation method of measuring Hall's effect, to eliminate thermoelectric and other perturbations; discussion of the possible sources of error. Dissymmetry is explained as due to a difference in the increase of resistance in two principal directions, which directions are related to the mean trend of the crystallographic axes of the metal (bismuth). An investigation is given, with mathematical developments, of the distribution of current in a circular plate of bismuth, placed in a magnetic field, and calculation of the resistances in the principal directions. The mean Hall effect is not the same when an axis of symmetry lies directly between the electrodes and when it does not; this was traced to the state of aggregation of the bismuth. With very thin electrolytically deposited bismuth the bismuth is so irregularly deposited that outside a magnetic field the metal may be considered isotropic; but in a field not at right-angles to the plate it becomes not so; in a field at right-angles to such a plate the isotropism would persist, and there could be no true dissymmetry, only an apparent dissymmetry when the secondary electrodes are not equipotential. Any appreciable thickness of such a film will introduce another cause of apparent dissymmetry, the increase of resistance along the lines of force. A plate cut from a crystal at right-angles to the principal axis would be perfectly isotropic parallel to its faces, and would act as in the last-mentioned case; if cut parallel to that axis there would be anisotropism and dissymmetry in Hall's effect. In the ordinary bismuth plate made by casting we have crystals irregularly soldered together, and there is then no determinate Hall coefficient. [See also Abstract No. 2156 (1901).] A. D.

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CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

729. *The Periodic System.* **H. Staigmüller.** (Zeitschr. Phys. Chem. **39**. pp. 245–248, Dec. 5, 1901.)—The author constructs the following scheme, showing the position of the new gases :—

H	*He*	*Li*	*Be*	*B*	*C*								*N*	*O*	*F*		
1	4	7	9·1	11	12								14	16	19		
Ne	*Na*	*Mg*	*Al*	*Si*									*P*	*S*	*Cl*		
20	23	24·4	27·1	28·4									31·2	32·1	35·5		
Ar	*K*	*Ca*	*Sc*	*Ti*	*V*	*Cr*	*Mn*	*Fe*	*Ni*	*Co*	*Cu*	*Zn*	*Ga*	*Ge*	*As*	*Se*	*Br*
40	39·1	40	44·1	48·1	51·2	52·1	55·0	56	58·7	59	63·6	65·4	70	72	75	79·1	80·0
Kr	*Rb*	*Sr*	*Y*	*Zr*	*Nb*	*Mo*	*Ru*	*Rh*	*Pd*		*Ag*	*Cd*	*In*	*Sn*	*Sb*	*Te*	*J*
?	85·4	87·6	89	90·6	94	96·0	102	103	106		107·9	112	114	118·5	120	127	126·9
X	*Cs*	*Ba*	*La*	*Ce*													
?	133	137·4	138	140													
					Ta	*W*	*Os*	*Ir*	*Pt*	*Au*	*Hg*		*Tl*	*Pb*	*Bi*		
			Yb		183	184	191	193	195	197·2	200·3		204·1	206·9	208		
				Th		*U*											
				232		240											

S. R.

730. *Standard of Atomic Weights.* **T. W. Richards.** (Amer. Acad., Proc. 37. pp. 177–181, Aug., 1901.)—It is pointed out that oxygen has actually served as the experimental standard of reference in a great majority of cases, that a great bulk of valuable work has already been published on the basis $O = 16$ ($H = 1{\cdot}0075$), and that the use of this standard involves no important difficulties in teaching, while the decision in its favour of the International Committee should ensure its adoption, since uniformity of usage is more important than any of the special advantages that have been suggested for other standards. S. R.

731. *Atomic Weight of Calcium.* **F. W. Hinrichsen.** (Zeitschr. Phys. Chem. 39. pp. 311–322, Dec. 13, 1901.)—The author has redetermined the atomic weight of calcium in calcite and has found that when $O = 16$ $Ca = 40{\cdot}142$. S. R.

732. *Intimate Structure of Crystals. Cubic Crystals with Octahedral Cleavage.* **W. J. Sollas.** (Roy. Soc., Proc. 69. pp. 294–306, Jan. 31, 1902.)—Continuing his former investigations [see Abstract No. 1144 (1901)] the author deals with the compounds cuprite, Cu_2O, tenorite, CuO, silver sulphide, and fluorspar, in which the simplest molecule contains three atoms of two kinds. If the paired atoms be approximated, but not so as to touch, and two molecules be placed at right-angles, the lower one inverted, the result will be enclosed by octahedral planes, and may be regarded as the crystalline element from which other forms are built up. Diagrams are given of the probable grouping of these primitive octahedra in the different compounds, and the dimensions are calculated from the diameters of the atoms derived from the atomic volumes. The results of geometrical construction, and also of the calculations of Mr. H. Hilton, of Magdalen College, explain many physical phenomena, such as cleavage, gyrohedry, changes of volume by heat, and varying hardness in different directions. The paper cannot be properly understood without the figures, of which there are ten. S. R.

733. *Relations of the Viscosity of Liquids to the Temperature and to Chemical Constitution.* **A. Batschinski.** (Soc. Imp. Nat. Moscou, Bull. 1. 2. pp. 1–101, 1901.)—With the object of testing the validity of the law, $\eta T^3 = E =$ a constant, η being the internal friction of a liquid, and T the absolute temperature at which the measurements are made, the author brings together the results of a large number of viscosity determinations made by various investigators. The relation is found to hold with: (1) Bromine and nitrogen dioxide; (2) 10 aliphatic hydrocarbons; (3) 20 out of 30 halogen derivatives examined; (4) 1 of 6 nitro-compounds, the data in the other cases not being very accurate; (5) 3 out of 5 sulphur derivatives; (6) 5 out of 10 aldehydes and ketones investigated; (7) 6 ethers; (8) 5 out of 13 aromatic compounds. Anhydrides, acids, alcohols, and water (below its boiling-point) in general do not obey the law, whilst of the 38 esters examined, some obey the law fairly well, and the same is the case with some others at high temperatures only, but for many of these compounds the data accessible are insufficient. T. H. P.

734. *Surface-tensions of Mixed Liquids.* **W. H. Whatmough.** (Zeitschr. Phys. Chem. 39. pp. 129–193, Dec. 5, 1901.)—The surface-tensions of liquids may be compared by determining the pressure necessary to drive a stream of air-bubbles through a capillary point immersed in the liquid. Under certain

conditions the method is capable of exceedingly great accuracy—nine out of twelve values for carbon disulphide and seven out of eight values for benzene differing by less than 0·1 per cent. from the mean ; to secure these results the capillary point must not be more than 2 cm. long, and must be of such a degree of fineness that the pressure at which bubbles are forced through the liquid is equal to that exerted by a column of sulphuric acid from 80 to 200 cm. high. The determinations are only relative ; for salt solutions the standard taken was water, $\gamma = 7{\cdot}557$ at 18°, and for organic liquids alcohol, $\gamma = 2{\cdot}413$ at 18°.

In accordance with the statement of Quincke (Pogg. Ann. 160. 337 and 500) the surface-tension of a series of aqueous solutions for chlorides was found to be expressible by a simple formula, $\gamma = 7{\cdot}577 + 0{\cdot}1857\ y$, where y is the number of equivalents of salt per 50 H_2O ; by this formula the surface-tensions can be calculated within 0·1 per cent. for all solutions up to 4N, except in the case of NH_4Cl and $CaCl_2$. In the case of the sulphates the constant is 0·1585 and in the case of the nitrates 0·1535.

Quincke and Harnack have found a difference in the surface-tension of freshly prepared solutions and those that have been kept some time ; this result could not be confirmed, and the maximum deviation observed after 24 hours in six solutions was only 0·1 per cent. Volkmann has given the formula $\gamma = u_1\gamma_1 + u_2\gamma_2$ for the surface-tension of a mixture of two substances in the proportion of u_1 to u_2 ; this formula holds good for mixtures of chloroform with acetone and with ether, benzene with acetone and toluene, methylal with isobutyl acetate, and water with hydrogen chloride and nitrate ; in three cases the differences between the observed and calculated values are all less than 0·1 per cent., and in the other cases usually less than 0·3 per cent. Mixtures of sulphuric acid and water exhibit a remarkable maximum of surface-tension at 46 per cent. H_2SO_4, corresponding with a minimum of compressibility ; this is an isolated case, but minima of surface-tension occur in mixtures of acetic acid with ethyl iodide, carbon tetrachloride, benzene and chloroform, toluene with xylene, ethyl acetate with amyl alcohol, carbon disulphide with ethylene dichloride, carbon tetrachloride with chloroform, and benzene with ethyl iodide ; in a number of cases, especially where the difference between the surface-tensions of the components is large, actual minima do not occur, but curves are obtained which exhibit a marked "sag," indicating a tendency towards a minimum ; this was observed to occur in mixtures of ether with benzene and with carbon disulphide, acetic acid with water, chloroform with carbon disulphide, and benzene with chloroform and with carbon disulphide.

In the case of liquids such as water and phenol, and water and isobutyric acid, which are only partially miscible, the surface-tensions of the two layers differ considerably at low temperatures, but become identical at the critical temperature when the liquids become miscible in all proportions ; similar results were found with the two layers in ternary mixtures, such as aniline and water with ethyl alcohol. T. M. L.

735. *Gypsum and Anhydrite.* **J. H. van't Hoff** and **F. Weigert.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 48. pp. 1140–1148, Nov. 28, 1901.)—The authors find that gypsum, $CaSO_4, 2H_2O$, changes gradually at 66° C. into natural anhydrite, $CaSO_4$; but at this temperature the change is almost too slow for measurement. Certain salts, however, lower the temperature of transition ; such salts must not react, nor form isomorphous mixtures with the $CaSO_4$. For this reason the salts used in these experiments are sodium

chloride and sodium bromide. The change from gypsum to anhydrite is investigated by means of a dilatometer. The molecular volume of $CaSO_4$, $2H_2O$ is 74·3, while that of $CaSO_4$ is 47 ; and of H_2O, 18 ; so that the change of a grm.-molecule of gypsum into anhydrite causes an expansion of 8·7 c.c. A saturated solution of NaCl lowers the point of change of gypsum into natural anhydrite, from 66° C. to 30° C. ; and into soluble anhydrite from 89° C. to 65° C. A saturated solution of sodium bromate changes the transition-point of gypsum to natural anhydrite, from 66° C. to 50°·2. The vapour tension of the mixture of gypsum and anhydrite at 30° C. is 24 mm., identical with that of the NaCl solution. At 50°·2 the tension is 83·3 mm. The transition-point of gypsum to the half-hydrate $CaSO_4$, $\frac{1}{2}H_2O$ is 107°, and 101°·5 under atmospheric pressure ; magnesium chloride lowers the point to 11° and sodium chloride to 76°. From solutions of calcium sulphate which have a lower tension than 17·2 mm. at 25°—for instance, sea-water—the sulphate is deposited as anhydrite. [See also Abstract No. 1721 (1901).]

W. C. *B.*

736. *Chemical Equilibrium in the Iron-Carbon System.* **G. Charpy** and **L. Grenet.** (Comptes Rendus, 134. pp. 103–105, Jan. 13, 1902.)—In order to ascertain the influence of silicon in determining the separation of graphite from cast iron, experiments were made with iron containing a fairly constant proportion of carbon, an amount of silicon varying from 0·05 to 2 per cent., and only traces of other impurities. The conclusions arrived at are as follows : (1) The temperature at which the separation of graphite begins is lowered by the presence of silicon. (2) The separation of graphite when once started will continue at lower temperatures. (3) The rate of separation decreases as the temperature falls and as the proportion of silicon decreases. (4) In a state of equilibrium the proportion of graphite is only slightly dependent on the amount of silicon present. (5) This proportion increases with falling temperature, and at low temperatures the proportion of combined carbon *in a state of equilibrium* appears to become zero. T. M. L.

737. *Solubility of Gypsum in Aqueous Solutions of Certain Electrolytes.* **F. K. Cameron** and **A. Seidell.** (Journ. Phys. Chem. 5. pp. 643–655, Dec., 1901.)—The solubility of calcium sulphate in water (2·1 grm. per litre) is decreased by the addition of calcium chloride until with 368 grm. $CaCl_2$ per litre it is reduced to 0·03 grm. per litre, and would apparently become zero in presence of 375 grm. $CaCl_2$ per litre. Sodium sulphate, which also contains a common ion, produces at first a similar effect, the solubility falling to 1·41 grm. $CaSO_4$ per litre in presence of 16·36 grm. Na_2SO_4 ; but a further addition causes an increased solubility, probably owing to the formation of a double salt. Magnesium chloride and sodium chloride, which contain no common ion, increase the solubility of calcium sulphate in water, but maximum values are reached at 7·5 grm. $CaSO_4$ per litre in presence of 140 grm. NaCl, and at 8·6 grm. $CaSO_4$ per litre in presence of 121 grm. $MgCl_2$; beyond this the addition of the chloride produces a decrease of solubility, and the solubility of calcium sulphate is almost the same in presence of 400 grm. $MgCl_2$ per litre as in pure water. The presence of chalk in contact with the solution diminishes the solubility of calcium sulphate in presence of sodium chloride, especially in the more concentrated solutions ; and the solubility curve shows a fairly sharp peak at 6·4 grm. per litre in presence of 0·0603 grm. $CaH_2(CO_3)_2$, and 79·5 grm. NaCl per litre in place of the smooth maximum observed in the absence of chalk. T. M. L.

738. *Distribution Ratios of Solutes.* **A. Hantzsch** and **A. Vagt.** (Zeitschr. Phys. Chem. 38. pp. 705–742, Nov. 1, 1901.)—The ratio of distribution of a solute between two solvents is found to be almost independent of the concentration and of the temperature in those cases in which the molecular condition of the solute is the same in both solvents. Values almost independent of the temperature were found in the case of mercuric chloride in water and toluene ($c_1/c_2 = 11{\cdot}20$), hydrogen cyanide in water and benzene ($c_1/c_2 = 3{\cdot}80$), ethylene cyanide in water and chloroform ($c_1/c_2 = 1{\cdot}7$), acetone in water and toluene ($c_1/c_2 = 2{\cdot}05$), formaldehyde between water and ether ($c_1/c_2 = 9{\cdot}0$), chloral hydrate between water and ether ($c_1/c_2 = 0{\cdot}234$), and between water and toluene ($c_1/c_2 =$ about 64), where c_1 and c_2 are the concentrations in grm.-molecules per litre of the solute in the first and second solvents respectively. For trimethylamine dissolved in water and toluene the ratio was found to decrease from 7·24 at 0° to 0·448 at 100°, that of triethylamine in water and toluene from 0·395 at 0° to 0·061 at 90°, that of pyridine in water and toluene from 0·840 at 0° to 0·307 at 90°, and that of collidine in water and toluene from 0·0603 at 0° to 0·0218 at 90°. This result is not due to electrolytic dissociation, which does not occur to any appreciable extent in pyridine and collidine, and in the case of trimethylamine and triethylamine is only slightly affected by temperature. It is suggested that hydrates are formed in the aqueous layer, and that these are broken up as the temperature rises; this view is supported by the fact that ethylene diamine and hydramine, which form stable hydrates, $C_2H_4(NH_2)_2$, H_2O and N_2H_4, H_2O, remain entirely in the aqueous layer, and cannot be extracted by ether. For bromine between water and air the ratio decreases from 63·15 at 0° to 6·05 at 60°, probably owing to the decomposition at higher temperatures of the hydrate $Br_2 + 10H_2O$. The ratio of distribution of iodine in glycerol and chloroform falls from 0·675 at 0° to 0·330 at 50°, whilst in glycerol and ether it remains constant at 0·20. Probably compounds with the solvent are present in the brown solutions in glycerol and ether, but not in the violet solution in chloroform, and this view is confirmed by Vaubel's observation that solutions of iodine in dilute sulphuric acid are brown, whilst solutions in strong sulphuric acid are violet. Beckmann and Stock have shown that in all solvents the iodine molecule is diatomic. For carbon dioxide in water and air the ratio falls from 1·972 at 0° to 0.38 at 90°, whilst in toluene and air it is relatively steady at about 3·0, as is also the ratio for ammonia in toluene and air at 7·7; this is taken to indicate the formation of hydrates in the aqueous layer. For ferric sulphocyanide in water and ether the ratio *increases* as the temperature rises from 0·532 at 0° to 4·32 at 35°, and that of chromiumsulphocyanide from 0·768 at 0° to 1·720 at 30°; this behaviour is directly opposite to that of all the other substances examined, and is taken to indicate the formation of a compound with the ether. For mercuric chloride between water and toluene and for bromine between water and air the ratio is independent of the concentration, but this is not the case with iodine in glycerol and chloroform, trimethylamine, triethylamine and piperidine in water and toluene, and especially ferric sulphocyanide in water and ether, indicating that the formation of "hydrates" is in these latter cases only complete at great dilution. The additions of acids, bases, and salts has no appreciable effect on the distribution of ethylene cyanide between water and chloroform, and acids and salts do not affect the equilibrium of hydrocyanic acid in water and benzene, acetic acid in water and ether or carbon dioxide in water and air, but the distribution of monochloroacetic acid in water and ether is much affected by the addition of sulphuric acid owing to the repression of the

electrolytic dissociation; this explanation cannot, however, be given in the case of the trialkylamines, in which the ratio is much reduced by the addition of alkalies but not by the addition of the amine hydrochloride to the aqueous layer. T. M. L.

739. *Oxidation of Ferrous Solutions by Free Oxygen.* **J. W. McBain.** (Journ. Phys. Chem. 5. pp. 623–638, Dec., 1901.)—The author gives the results of a number of experiments on the oxidation of solutions of ferrous sulphate, chloride, and acetate by mixing them with solutions of oxygen, the proportion of ferric ions being determined from time to time by means of ammonium sulphocyanide solution. Investigation of the oxidation of dilute sulphuric acid solutions of ferrous sulphate shows that the rate at which the action takes place is proportional to the concentration of the oxygen. The constants calculated according to the equation of reactions of the first order are very nearly proportional to the squares of the concentrations of the ferrous sulphate, even between such wide limits as N/2 and N/50; the influence of sulphuric acid on the reaction is practically nothing when its concentration lies between N/50 and N/10, but by raising the value to N/2 the constant is diminished in the ratio of about 3 : 2. The reaction must hence be regarded as trimolecular. Experiments with ferrous chloride solutions show that the velocity of oxidation is proportional to the square of the concentration of the iron in the stronger solutions, whilst for N/10 to N/50 the relation closely approaches direct proportionality; concentrated hydrochloric acid increases the rate of oxidation, but the dilute acid has no appreciable action. With ferrous acetate solutions the speed of oxidation is approximately proportional to the cube of the concentration of the salt, and the reaction appears to be tetramolecular; the corresponding acid exerts a retarding influence, which is, however, more marked than in the case of the sulphate, whilst the addition of sodium acetate greatly increases the speed of the reaction. T. H. P.

740. *Lithium Antimonide and other Lithium Alloys.* **P. Lebeau.** (Comptes Rendus, 134. pp. 231–233, Jan. 27, 1902.)—Lithium and antimony combine easily on heating with production of much heat. The author endeavoured to obtain the compound in a pure state by heating the antimony together with an excess of lithium, and after the reaction dissolving out the remaining lithium by means of liquefied ammonia. This process does not give good results, owing to the violence of the reaction. A pure product, of the formula $SbLi_3$, may, however, be obtained by the electrolysis of a fused mixture of equal quantities of LiCl and KCl, using a graphite anode and an antimony kathode. The compound is of perfectly definite composition, highly crystalline, and acts on water in the cold with production of pure hydrogen; its melting-point is much higher than those of its constituents. This electrolytic method may be employed to produce various lithium alloys, and antimonides and arsenides of the other alkaline metals. W. C. B.

741. *Alloys of Aluminium with Iron and with Manganese.* **L. Guillet.** (Comptes Rendus, 134. pp. 236–238, Jan. 27, 1902.)—An examination of the iron-aluminium alloys obtained by heating aluminium with ferric oxide led to the isolation of the crystalline compound Fe_2Al_3; this corresponds in composition to the maximum point in Roberts-Austen's fusibility curve. A further crystalline alloy, $FeAl_3$, and similar manganese compounds, Mn_2Al_3, $MnAl_2$, and $MnAl_4$, were isolated. D. H. J.

742. *Pure Seleniuretted Hydrogen.* **de Forcrand** and **Fonzes-Diacon.** (Comptes Rendus, 134. pp. 171–173, Jan. 20, 1902.)—The gas was obtained pure and dry by the action of water on excess of aluminium selenide. It was soluble in water to the extent of 3·77 vols. at 4°, of 3·43 vols. at 9°·65, of 3·31 vols. at 13°·2, of 2·7 vols. at 22°·5. Liquid H_2Se has a density of 2·12 at its boiling-point, −42°; at low temperatures it changes to a white solid of melting-point −64°. D. H. J.

743. *Vapour Tension of Hydrogen Selenide and Dissociation of its Hydrate.* **de Forcrand** and **Fonzes-Diacon.** (Comptes Rendus, 134. pp. 229–231, Jan. 27, 1902.)—The vapour tension of H_2Se is known to be 760 mm. at −42° C. By using Cailletet's apparatus the authors find the tension at 0°·2 C. to be 4·5 atmospheres, and at 30°·8 C. to be 12 atmospheres. In order to obtain the tension at another point the gas was put into the shorter arm of a Boyle's tube, which was cooled to −30° C. by a bath of liquid methyl chloride through which a current of air was passed; the pressure found was 1·75 atmospheres. From these four values the curve may be constructed and the heat of vaporisation of H_2Se obtained; this is found to be 4·74 calories. The hydrate may be obtained by filling a flask with damp hydrogen selenide, and exposing it to a temperature of about 5° C. It is a colourless crystalline substance of about the same stability as chlorine hydrate. Its tension of dissociation was measured at several temperatures. W. C. B.

744. *Spontaneous Decomposition of Ozone.* **E. Warburg.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 48. pp. 1126–1139, Nov. 28, 1901.)—The proportion of ozone in ozonised oxygen gradually diminishes on standing. This decomposition may be due to traces of impurities, or to the instability of the ozone molecule; in the latter case each ozone molecule may break down independently of the others, when the reaction will be monomolecular; or two molecules may react so as to produce mutual decomposition, in which case the action will follow a bimolecular course. The apparatus used is similar to that employed by the author in a former research [see Abstract No. 2067 (1900)], the chief difference being that the ozone is only allowed to come into contact with glass and sulphuric acid, and not with platinum as in the earlier experiments. The apparatus consists essentially of two glass vessels of equal size, connected by a capillary U-tube containing a thread of sulphuric acid. Before the gas in one of the vessels has been ozonised, the level of the H_2SO_4 is the same in each limb of the capillary; the amount formed can be calculated from the contraction, and the rate of spontaneous decomposition from the gradual return of the thread of acid to its original level. Series of experiments were made at 17° C., 100° C., and 126°·9 C., sulphuric acid, soda-lime and phosphorus pentoxide being used as drying agents. It is found that the drying agent used exerts no influence on the stability of the ozone, except that commercial phosphorus pentoxide, owing to the presence of lower oxides, rapidly destroys the ozone; when purified by distillation over red-hot platinum it loses this property. The author finds that at a low temperature (17° C.), the velocity of spontaneous decomposition is small compared with that due to impurities in the ozone, but that as the temperature is raised the former velocity quickly increases. The reaction is bimolecular, and proceeds according to the following equation: $dC = -\beta_1 . C^2 . dt$ where C = the mass of ozone in grammes per litre; t is the time in minutes, and β_1 a value depending on the temperature. B_1 has the value 0·00000204 at 17° C., 0·0157 at 100°, and 0·177 at 126°·9 C. It is impossible to obtain any further alteration

in volume by raising the temperature of ozonised oxygen which has been heated to 180° C.; but oxygen, at a temperature of 200° C., may be ozonised to the extent of 1·5 parts per mille by means of an induction apparatus. Finally the author examines Shenstone's statement that dry ozone is less stable than the damp gas (Chem. Soc., Jour. p. 477, 1897) by placing ozone in contact with a diluted sulphuric acid of the formula $H_2SO_4 + H_2O$. His results, at a temperature of 100° C., do not agree with those of Shenstone.

W. C. B.

745. *Alkalichloride Electrolysis with Carbon Anodes.* **L. Sproesser.** (Zeitschr. Elektrochem. 7. pp. 971–976, Nov. 7; 987–994, Nov. 14; 1012–1017, Nov. 21; 1027–1035, Nov. 28; 1071–1076, Dec. 12; and pp. 1083–1093, Dec. 19, 1901. Communicated by the Elektrochem. Labor. of the Dresden Institute.)—As the production of good carbon anodes is of great importance in the technical electrolysis of alkali chlorides, the author has made a comparative research on the general properties of various forms of carbon, and on their behaviour when used in electrolysis. The following varieties were used: three sorts of retort carbon, seven of manufactured anodes, and one variety of graphite. The true specific gravity varied from 2·07 to 2·10 for the retort carbons, and the apparent sp. gr. from 1·71 to 1·86. For the artificial carbons the true sp. gr. ranged from 1·94 to 2·03, and the apparent sp. gr. from 1·47 to 1·64; from the ratio of the real to the apparent sp. gr. the author determines the porosity of the carbon. Determinations of the ash left on combustion are also given. The carbons used as anodes were plates 7 cm. long, 4·5 cm. broad, and 1 cm. thick; two platinum plates 6 × 2·5 cm. served as kathode. The electrolytic cell was a beaker containing about 250 cub. cm. of a solution of KCl, 200 grams per litre; in later experiments this was replaced by a solution of NaCl, 200 grams per litre, to prevent separation of the chlorate. The cell was provided with an apparatus for collecting the gases evolved, and was placed in circuit with a copper sulphate, a water voltameter, and an ammeter. A large number of experiments were made with the different carbons, under varying conditions of temperature, current, and concentration of the electrolyte. Control experiments were also made with platinum anodes. Tables are given showing for each experiment the oxygen and CO_2 evolved, and the hypochlorite and chlorate produced. The total active oxygen produced is greater with platinum than with carbon, as the carbon is always attacked to some extent with production of CO_2; the amount of this attack varies considerably, from 8 per cent. for the retort carbons to 19 per cent. for the manufactured anodes. The losses of anodes composed of the different carbons by precipitation of carbon, and by solution and evolution of CO_2, is also tabulated. A further section of the research deals with electrolysis in cells containing a porous clay diaphragm. The author also shows that the liberation of gases, due to the porosity of the carbon, is not the principal cause of the breaking up of the carbon, but that this is due primarily to chemical actions. The destruction of the anodes was more rapid at higher temperatures. The best anodes are generally those composed of the least porous carbons, but it is not possible to judge of the suitability of a carbon simply from its porosity. Researches on the electrolysis of various other solutions with carbon electrodes, and on the oxidation of carbon by hypochlorous acid are also given. The author concludes with a summary of the various methods of testing carbons with reference to their use as anodes in alkalichloride electrolyses.

W. C. B.

746. *Electrolysis of Fused Salts.* **R. Lorenz.** (Electro-Chemist, 1 pp. 267–268, Dec., 1901.)—The author criticises some of Garrard's results on electrolysis of fused salts, particularly fused $PbCl_2$. The latter found two "kink" points in the decomposition voltage curve of fused $PbCl_2$, and one in the case of salts of the type of AgCl. The first point occurs at 0·8 volts (temperature 600° C.), and, according to Garrard, corresponds with the equation (1) $PbCl_2 = \overset{++}{Pb} + \bar{Cl} + \bar{Cl}$; the second at 1·2 volts with the equation (2) $PbCl_2 = \overset{+}{PbCl} + \bar{Cl}$. The author considers that the first point is caused by depolarisation phenomena, and that the second corresponds with equation (1). If the first point corresponds to equation (1) it should be independent of experimental conditions; this, the author finds, is not the case. By placing the electrodes near together, the depolarisation and the diffusion of metal in the form of "fog" [see Abstract No. 425 (1901)] increase, and the point may fall to 0·6 volt; by increasing the distance apart of the electrodes the value increases, until the "kink" point disappears from the curve. When there is only one point at 1·2 volts the current yield is 100 per cent., when there are two it is always less. This e.m.f. of 1·2 volts is also identical with the e.m.f. of polarisation on electrolysing $PbCl_2$, and with the e.m.f. of a cell containing carbon | chlorine gas | fused $PbCl_2$ | lead. For these reasons the author concludes that the second "kink" point of Garrard's curve corresponds to the reversible reaction of equation (1). Adopting certain conditions, the author deduces from the first law of thermodynamics his empirical formula $\epsilon/\epsilon_0 = \alpha$, where α is the current yield and ϵ_0 and ϵ the counter electromotive forces. He shows that the principle that ϵ (the counter e.m.f. in the electrolytic bath) is proportional to α is applicable to the commercial electrolytic production of potassium, sodium, and magnesium, and to the Héroult cell for the production of aluminium. This principle also explains the increased yield obtained by cooling the kathode, and by adding certain substances; in both cases the solubility of the metal and the tendency to form "fog" are diminished, the polarisation is diminished, and the current yield consequently increased. These metal "fogs" also explain the various suboxides and subchlorides said to form at the kathode; in reality these are simply metal solutions in the electrolyte. Finally the diffusion of metal in this form explains the results of electrolysis with diaphragms, through many of which the metal "fogs" are unable to pass. [See also Abstract No. 2225 (1901).] W. C. B.

747. *Passive Iron.* **A. Finkelstein.** (Zeitschr. Phys. Chem. 39. pp. 91–110, Nov. 12, 1901.)—An electrode of passive iron can be balanced in a Wheatstone bridge with an alternating current of small magnitude by means of a condenser of large capacity short-circuited with a very small resistance; it therefore behaves very much like platinum and gold, and its special properties cannot be due to a non-conducting film of oxide. There is a definite e.m.f. at which an iron anode becomes passive; this is independent of the acidity of the solution, and depends only on the amount of iron in the solution, affording fresh evidence that the passivity is not due to a layer of oxide. The view adopted is that passive iron is a metallic modification of the element, which resembles the noble metals and is capable of absorbing oxygen. T. M. L.

748. *Structure of the Atom and the Ionic Theory.* **F. Lengfeld.** (Journ. Phys. Chem. 5. pp. 639–642, Dec., 1901.)—The author discusses the bearing on the ionic theory, the solution tension theory, and the periodic law of

J. J. Thomson's work on the structure of the atom. Thus sodium chloride may dissociate into chlorine atoms plus one corpuscle and sodium atoms minus one corpuscle, and it may be supposed that in electrolysis the chlorine ion may be neutralised at the anode, the neutral atom of n corpuscles being stable, but that of $n+1$ unstable, and the extra corpuscles set free may diffuse through the solution and at the kathode add on to the sodium ions, or replace in the kathode the corpuscles that have been taken up by the sodium ions. He suggests in explanation of the fact that a metal plate becomes negative when placed in water, that diatomic metal molecules may go into solution, and there split up into positive ions (1 atom minus 1 corpuscle) and negative ions (1 atom plus 1 corpuscle), and that the negative ions may be less soluble than the positive deposit on the zinc. Lastly, regarding the arrangement of the corpuscle in the atom as that of Mayer's group of magnets floating in a magnetic field, each atom is made up of nucleus and periphery, and certain properties, *e.g.*, group properties, may depend on the shape &c. of the nucleus, others on the periphery. [See also Abstract No. 1294 (1900).]

W. E. T.

748. *Luminous Phenomena at Aluminium and Magnesium Electrodes.* **S. A. Berti.** (Elettricista, Rome 11 pp. 1-2 Jan. 1902.)—When a solution of sodium potassium tartrate is electrolysed between aluminium electrodes, there ensues (at the anode with a direct current, at both electrodes with an alternating current) a fluorescence which at 250 volts changes to an appearance of continuous luminosity. The author ascribes the effect to the formation of a badly conducting layer of oxide on the electrode, shows that magnesium may replace the aluminium, and identifies the phenomenon with that observed by Tommasina [see Abstract No. 498 (1900)] during the discharge of an induction coil through alcohol or water. Instead of the tartrate, other solutions may be used, viz., dilute potash, soda or ammonia carbonate and phosphate of potash or of sodium, potassium bichromate and ammonium carbonate.

D. H. J.

REFERENCES.

750. *Comparison of Notations Employed in Memoirs on Crystal Structure and Revision of the 230 Groups of Mathematics.* **H. Hilton.** (Phil. Mag. 3 pp. 205-212 Feb., 1902.)

751. *Properties of Steel Castings.* **J. O. Arnold.** (Metallographist 5 pp. 2-24 Jan. 1902. Paper read before the Iron and Steel Institute May, 1901.)—The paper deals very fully with the physical and chemical questions affecting this very complex subject.

O. J. S.

752. *Apparatus for Demonstration of the Motion of Ions.* **R. Abegg.** (Phys. Zeitschr. 3 pp. 110-112 Dec. 15, 1901.)—The article describes an apparatus for demonstrating and measuring the velocity of the surfaces of separation of a solution, gel, and liquid electrolytes. The apparatus consists of [illegible] tubes with two electrodes each, arranged in a glass tank. Its use is explained in detail.

G. H. B.

753. *Electrochemistry.* **H. C. Jones.** (Elect. Rev. N.Y. 39 pp. 65-68, 75-87, 121-124, 150-152, 182-185, 209-212, 273-277, 300-307, 334-342, 372-376, and pp. 402-405, 1901.)—A series of articles giving a clear account of the ionization theory and its foundations, more particularly with reference to voltaic cells.

W. R. C.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

754. *Engines for Large Traction Plants.* **W. Kent.** (Street Rly. Journ. 18. pp. 293–309, Oct., 1901.)—The three plants referred to are those of the Metropolitan Street Railway Company, the Third Avenue Railway Company at Kingsbridge, and the Manhattan Railway Company. [See Abstracts Nos. 1373 (1900) and 977 (1901).] The primary consideration in such large stations is continuous operation, running economy coming next, and first cost last. The use of Corliss valves on the high-pressure cylinders of the engines used in these plants prevents the utilisation of superheated steam, while those for the low-pressure cylinders are of enormous size, difficult to lubricate, and, being unbalanced, probably require considerable power to operate them. The author compares these types of engines with marine engines, such as those to be used on H.M.S. *King Alfred*—two engines, triple expansion, four cylinders, 43½, 71, 81, 81 in. dia. by 48 in. stroke ; 120 r.p.m., steam pressure at engines 250 lbs. per sq. in., rated h.p. 15,000. There seems to be no good reason why such engines as these should not be well adapted for a power station ; they would develop about 11,000 h.p. at the most economical rate, and a maximum of about 16,500 h.p., while the engines are in fact smaller than the Manhattan ones, though of 37½ per cent. greater power. The running conditions of such an engine driving an alternator on land would be much less severe than those of a marine engine. The general conditions required of the latter are that it must be of minimum weight and occupy minimum space for the power required, it must economise fuel to the highest degree, must be balanced, as its only foundation is the hull of the vessel, must be capable of running for eight days and nights without stopping, and must run with very little oil. These power stations have engines of great size and weight per h.p. ; slow rotative speed, involving large size and cost of alternators, extensive foundations, and waste of space ; unbalanced rotating valves ; low steam pressure without superheating ; only two stages of expansion, and a maximum economy of 13 lbs. of steam per i.h.p.-hour. The author considers that an engine on the lines of the best marine practice, running at not less than 100 r.p.m., would do the work for between 10 and 11 lbs. of steam per i.h.p.-hour, and that such engines are likely to be adopted before long in large power stations, when the engines of these three large plants may come to be regarded as magnificent examples of a transition period in power-plant engineering. H. R. C.

755. *Power for Driving Marine Engine Works.* **J. Crighton** and **W. G. Riddell.** (Inst. Mech. Engin., Proc. 4. pp. 959–973 ; Discussion, pp. 974–976, Sept., 1901.)—The costs of driving the main shafting, gearing, and machine tools, and the electric lighting apparatus of an engineering works by means of two different installations—an old and a new one—are compared. The basis of comparison is the cost of removing one ton of metal by machines, and this is arrived at by taking the weight of all turnings, &c., for a fixed period, and dividing this by the cost of one h.p. for the same period.

The old installation of power plant comprised one marine-type boiler working at 80 lbs. per sq.-in. pressure (the feed-water being heated to 205° F.),

and supplying steam to three vertical compound non-condensing engines for driving shafting and machines, and one vertical compound engine for lighting. The new set has one Scotch marine boiler with three furnaces, working pressure 200 lbs. per sq. in., and one vertical double-acting compound engine worked non-condensing. Forced draught is used, and the feed-water is heated to 205° F. by an exhaust steam heater.

The three engines under the old system collectively developed 151·2 i.h.p., and the lighting engine 64·66 i.h.p. The boiler evaporated 6·75 lbs. water per lb. coal, and the engines used 43·8 lbs. water per i.h.p.-hour. This gave a coal consumption of 6·4 lbs. per i.h.p.-hour.

The new boiler has 2,040 sq. ft. heating surface and 46·2 sq. ft. grate area, and an equivalent evaporation of 11·5 lbs. water from and at 212° F. has been frequently maintained. The engine developed 147·27 i.h.p. when driving the electric light apparatus alone; 61·75 i.h.p. when driving only the line shafting and loose pulleys; 141 i.h.p. when the machines and countershafts were added, and 210 i.h.p. when the machines were cutting at normal rate.

The line shafting (2,300 feet long, 3¼ in. dia., weighs 37 tons 8½ cwts., and runs at 140 to 150 revs.) absorbs 29·3 per cent. of the total power, countershafts and machines 67 per cent., and only 33 per cent. is applied to the cutting tools.

Various kinds of coal were tried, and the best results were obtained with steam coal at 11s. 6d. per ton. The ascertained costs were as follows:—

	Old system.	New system.
Material removed per annum	245 tons	367 tons
„ „ per i.h.p. per annum...	1·61 „	1·74 „
Cost of removing 1 ton of material	£5·21	£2·48

In the discussion **A. Saxon** considered the friction of engine and shafting rather high. An economiser heating the feed to 250° or 300° would give improved results. **W. H. Allen** found that 25 per cent. was taken up in the shafting, 25 per cent. in the top gearing, the smaller tools requiring 30 per cent., and the larger tools 20 per cent. of the energy given out by the generator in an engineer's shop, so that the work done in actual cutting was not more than 25 per cent. Some of this waste could be abolished by using the clutch system. **J. Crighton,** in reply to **B. Donkin,** stated that the boiler efficiency varied from 68 to 73 per cent.—as high as 78 per cent. had been attained. F. J. R.

756. *Modern Boiler Problems.* **E. D. Meier.** (Power, N.Y. 21. pp. 28–29, Dec., 1901. Paper read at the meeting of the New England Cotton Manufacturers' Assoc., Sept., 1901.)—Increased demand for, and altered conditions of, steam-power have rendered departure from formerly recognised standards necessary. Furnace capacity and efficiency can no longer be confounded with boiler capacity and efficiency, just as the boiler must now be considered apart from the engine. Modern conditions include the combustion of 25 lbs. with natural, and 35 to 50 lbs. with forced, draught per square foot of grate area per hour; steam pressures of 150 to 200 lbs. per square inch and even more, and feed-water temperatures very much above the old 100° or 110° F. The range of qualities of fuel to be used is also much greater; even the different grades of size of good coal produce different results. Thus good bituminous produces 7·1 h.p. per square foot of grate; anthracite egg 5·8, pea coal 4·4, buckwheat coal, 3·6, and rice coal 3 h.p. As length of grate is limited even with mechanical stokers, width becomes the measure of power

with low-grade fuels. Heating surface must be disposed to meet such a requirement. The high steam pressures render large diameters and all collapsing stresses undesirable. Great economy demands high furnace temperatures and ample combustion space so that the gases are not quickly cooled by the heating surface. These and other considerations point to the suitability of water-tube boilers as compared with either internally fired or externally fired cylindrical shell boilers. F. J. R.

757. *Size of Lever Safety Valves.* **R. A. Douglass.** (Amer. Electn. 14. pp. 14–17, Jan., 1902.)—The rules for determining the proper size of safety valves to be used on any given boiler are not in a very satisfactory state, neither the actual "lift" of safety valves nor the actual rate of discharge of steam through them being clearly known. Properly speaking, a safety valve should be competent to discharge steam at the maximum rate at which the boiler can produce it, but elements are wanting to enable such a valve to be designed. The valve seat being conical, the vertical lift of the valve must be multiplied by the sine of the angle made by the surface of the seat with the vertical centre line of the valve, in order to obtain the width of the ring formed by the opening of the valve by a given lift. The author gives in tables the results of experiments on the extent of lift of lever safety valves at pressures from 10 lbs. to 100 lbs. per square inch, made by the U.S. Board of Supervising Inspectors, and also figures giving the effective discharge areas of valves of different diameters at these pressures, on the assumption that the angle referred to is one of 45°. Taking Napier's rule for outflow of steam through an orifice as applicable to valves (which is not strictly true) he finds that at the various pressures (in lbs. per sq. in.) the following shows the number of lbs. of steam discharged through an orifice 1 inch square in one minute :—

Gauge pressure : 10, 20, 30, 40, 50, 60, 70, 80, 90, 100lbs.
Steam discharge : 21·4, 30·0, 38·6, 47·1, 55·7, 64·3, 72·9, 81·4, 90·0, 98·6lbs.

From these data a table is given showing pounds of steam discharged per minute by lever safety valves of different diameters at the different pressures. This table reveals some anomalies which call for experimental research.
F. J. R.

758. *Transfer of Heat from Steam to Water.* **H. L. Hepburn.** (Power, N.Y. 21. pp. 18–20, Dec., 1901.)—Whilst the thermal conductivity of thin partitions of iron or copper may be dealt with as if the conductivity of the metal were infinite, that of water is so low that a sheet of it $\frac{1}{2}$ inch thick will transmit only about $12\frac{3}{4}$ B.Th.U. per square foot per hour per deg. difference of temperature between the two faces. The particles of water, however, take up heat very rapidly when in contact with the hot body, consequently in the absorption of heat from a metallic surface by water in contact with it, the amount of stirring or the velocity of the water over the heating surface is an essential factor. Dealing with the formula proposed by C. P. Poole : $W \log_e (T_s T_o)/(T_s T_d) = AU$, in which W=number of lbs. of water per hour ; A = square feet of transmitting surface ; U = B.Th.U. absorbed by the water per square foot of surface per deg. of temperature difference per hour ; T_s = temperature of the hot surface ; T_o = temperature of entering water ; T_d = temperature of discharge water ; H = total number of B.Th.U. absorbed by the water per hour ; the author shows that the average difference of temperature throughout the time of an experiment will be less than that

usually supposed, viz. : $T_s - (T_o + T_d)/2$. Consequently, the usual formula $AU\{T_s - (T_o+T_d)/2\} = H$ does not provide for the increasing increment of surface required for each additional degree to which the discharged water is raised, the cost of such addition becoming practically prohibitive when the final temperature approaches 7 or 8 degs. of that of the heating medium. With Poole's formula, taking W as unity, all problems in heater work may be readily worked out in connection with a proper value of U, with given values of T_s, T_o and A ; T_s, T_o and T_d ; T_s, T_d and A ; or T_o, T_d and A. Taking U = 350 B.Th.U., and $T_s = 216°$ F., and deriving values of A for several values of T_o and T_d, the following gives the—

AREA OF HEATING SURFACE REQUIRED TO HEAT ONE POUND OF WATER PER HOUR.

Temperature of Entering Water (T_o).	Temperature of Leaving Water (T_d).			
	210°	205°	200°	195°
60°	0·009309	0·007578	0·006507	0·005730
70°	0·009119	0·007384	0·006316	0·005539
80°	0·008916	0·007186	0·006115	0·005344

In another table the author gives the results of experiments of *Nichols*, *Stanton*, *Richter*, *Hildreth*, and some by himself, worked out according to Poole's formula, and in a diagram several of these are plotted. The original paper should be consulted for these data.

Good American practice allows 1 square foot of surface in condensers for every 10 lbs. of steam to be condensed per hour at a vacuum of 25 inches of mercury and an initial temperature of 75° F. for the cooling water. About 25 lbs. of water per lb. of steam is allowed, and the condensed steam is reduced to a temperature of about 120° F. This amounts to heating 25 lbs. of circulating water from 75° to 116° F. per one-tenth square foot of surface per hour with steam at 133° F. By Poole's formula this gives U = 306·67. Taking into account the surface required to reduce the temperature of the condensed steam to 120° F. the value of U becomes 328·5 approximately, which corresponds with American practice in designing heaters. F. J. R.

759. *Heating Surface of Feed-water Heaters.* **J. E. Lewis.** (Power, N.Y. 21. pp. 30–31, Dec., 1901.)—Experiments made by Isherwood in 1867 showed that if the thermal conductivity of copper be taken as unity, that of brass is 87 per cent., wrought iron is 58 per cent., and cast iron 49 per cent. ; and that expressed in B.Th.U. these become copper 642, brass 557, and wrought iron 374. To calculate the surface required in feed-heaters, a formula is used in which these figures are modified by a constant to meet practical conditions. Thus $S = WD/ck\ (T - t)$ where S = the surface in square feet ; W = pounds of feed-water per hour ; D = the difference between the temperature of water on entering and leaving the heater ; T = temperature of steam in deg. F. ; t = mean temperature of the water ; k = Isherwood's value for the conductivity of the metal composing the heating surface, and c is a constant qualifying k. Loring and Emery made experiments on the U.S.S. *Dallas*, which gave c a value of 0·323 for condensers. Adopted for feed-heaters, this makes ck for copper

$642 \times 0{\cdot}323 = 207$, for brass $= 180$, and for wrought iron $= 120{\cdot}8$. In a 500-h.p. non-condensing plant, if the quantity of feed-water to be heated per hour from 50° to 212° F. is 500×30 lbs. per h.p. $= 15{,}000$ lbs., then $D = 212 - 50 = 162$; $T = 212$ and $t = 50 + \frac{162}{2} = 131$; $T - t = 212 - 131 = 81$; and $S = \frac{15{,}000 \times 162}{207 \times 81} = 145$ sq. ft., or 42 sq. in. per h.p. for copper. For brass this becomes 167 sq. ft. or $\frac{1}{3}$ sq. ft. per h.p.; and for wrought iron 250 sq. ft. or $\frac{1}{2}$ sq. ft. per h.p. Approximately, when the water is heated to the temperature of the steam, the surface can be calculated by dividing W by a constant $\frac{ck}{2}$, which is $= 100$ for copper, 90 for brass, and 60 for wrought iron. A quick rule, therefore, for computing the heating surface, knowing the amount of feed-water, and assuming that there is sufficient steam for the work, is to divide the feed-water in lbs. per hour by 100 for copper, 90 for brass, and 60 for iron coils. These results apply only to the water-tube heater.

F. J. R.

760. *Evaporative Surface Condensers.* **H. G. V. Oldham.** (Feilden, 6. pp. 107–120, Feb., 1902.)—Since steam users have learned the value of condensing plants, efforts have been directed towards simplifying the apparatus and minimising the loss of cooling water. The author reviews the progress made in this respect since his former paper [see Abstract No. 295 (1900)], and gives data and illustrations of several installations of successful evaporative condensers. It has been found that 2 lbs. of steam can be condensed per square foot of tube surface per hour without the use of water, but with air passing over the surface at a velocity of 1,000 feet per second. About 2,400 cub. ft. of air would be required for 1 lb. steam, 100 h.p. (at 20 lbs. steam per h.p.) requiring 1,000 sq. ft. of surface and 80,000 cub. ft. of air per minute. Without the use of a fan and without water, 125 sq. ft. would be required per lb. of steam condensed per minute, as against the above 30 sq. ft. per lb. steam per minute with a fan. When water is used, evaporative condensers are at work in which 2 sq. ft. of surface suffice per lb. of steam. These condensers necessarily have more surface than ordinary surface condensers, but the latter use about ten times the quantity of condensing water. In the case mentioned, the evaporative condenser had 3,000 sq. ft. of tube surface, and condensed all the steam from an engine indicating 50 h.p. which, taking 30 lbs. steam per i.h.p., gives a total of 1,500 lbs. steam per hour. Both vertical and horizontal tubes are employed in construction—the former came into use for condensers taking up small space, and not requiring more water than the ordinary supply for boiler-feed. Details and diagrams are given of the Thiesen, Wright, and Fraser condensers; and also of the horizontal and vertical open type, with either cast or wrought iron and copper tubes, which was introduced on account of difficulties connected with cleaning and working the vertical brass tube condenser. The open type occupies more space than the other, requiring about 1 sq. ft. of floor-space per 2 to 3 h.p. and a height of 10 ft. With wrought-iron tubes, 1 sq. ft. of surface will condense 2 to 3 lbs. steam per hour, with cast iron about $1\frac{1}{2}$ lbs. steam. The horizontal tube condensers of Ledward, Fraser, Kirkcaldy, and Cooper and Grieg are well illustrated, and details of several installations are given. Two plans are also given as typical of the latest practice for stations specially designed. The article concludes by noticing some important precautions to be observed in order to secure successful working.

F. J. R.

761. *Refuse Destruction.* **J. A. Priestley.** (Mech. Eng. 8. pp. 770–774, Dec. 7, 1901. Paper read before the Congress of the Royal Institute of Public Health, 1901.)—This paper describes the Meldrum destructor installed at Nelson, in combination with a Lancashire steam boiler, and a regenerator consisting of vertical cast-iron pipes through which the waste hot gases travel, which is placed in the circuit between the boiler and the chimney for the purposes of heating the air used for combustion. A record of tests made with the apparatus is given, Callendar's electrical recording pyrometer having been used for the temperatures, charts of which accompany the article. The CO_2 in the escaping gases was estimated by Orsat's apparatus at frequent intervals. The steam pressure in the boiler averaged 122 lbs. per square inch on an eight-hours' test, the fluctuations having been between 110 and 130 lbs.; the temperature of the combustion chamber ranged between 1,666° and 2,693° F., the average being 2,227° F.; and the CO_2 averaged 14·4 per cent., the maximum reading having been 19·8 per cent. The temperature of escaping gases was, however, 666° F., which, if utilised in an economiser, might have added 18 per cent. to the total evaporation. The total weight of water evaporated was 91,600 lbs. from feed at 83° F., giving an actual evaporation of 1·67 lbs. water per lb. refuse, or 1·96 lbs. from and at 212° F. The average hourly evaporation was 1,344 gals. from and at 212° F., which is said to have been equivalent to 13·6 lbs. of water per square foot of heating surface per hour. The refuse had a value, therefore, for steam raising of one-fifth that of coal. F. J. R.

762. *The "Potter" Mesh Separator.* **F. A. Scheffler.** (Power, N.Y. 21. p. 20, Dec., 1901. Presented at the New York meeting of the A. S. M. E., Dec., 1901.)—This device consists of a series of copper or galvanised wire meshes or screens placed vertically, and alternating with rings of cast iron, so that there is a small chamber or space between the meshes. There are usually 25 to 30 layers of mesh, which are held together by horizontal bolts passing through the series, but the area of the screens depends on the size of steam outlet from the boiler. The separator is placed in the steam space, one end exposing the screen to the steam. At the other end is a chamber from which a vertical steam-pipe leads. This is perforated in the portion which is inside the chamber, so that the steam after passing through the entire series of screens reaches and escapes by the pipe. Besides arresting any water, or filtering it out from the steam, there is a slight wire-drawing action, amounting to about 1 per cent. reduction of pressure, and a consequent slight superheating which further dries the steam. In any case it seems impossible for any priming water to escape through this device. Tests made on a 3,000-h.p. electric plant with and without the separator showed a decided advantage from its use. F. J. R.

763. *Water-hammer Steam-pipe Explosions.* **C. E. Stromeyer.** (Manchester Lit. and Phil. Soc., Mem. 46. 3. pp. 1–16, 1901–1902.)—Fracture by water-hammer may happen when water collects in the steam-pipe near the boiler stop-valve, as in that case, when the stop-valve is opened a plug of water is shot along the pipe to the engine, and will either break the valve there or the pipe. The author investigates the effect of sudden stoppage of an elastic body, and gives the formula $P = EV/W$ for the pressure exerted by it, and $t = L/W$ for the duration of the pressure, W being the velocity of sound in the body, E the volume elasticity, V the velocity suddenly destroyed, and L the length of the body. H. R. C.

764. *Cooling Towers.* **C. W. Obert.** (Amer. Electn. 13. pp. 475–478, Oct., 1901.)—The paper contains a description, with diagrams, of various commercial forms of towers used for cooling the condensing water of steam engines so that, with a small percentage loss by evaporation, the same water can be used over and over again. The water is made to fall in finely divided and broken-up streams, and may be cooled simply by falling through the air, or there may be an upward draught in the tower produced either by a fan or by connection to a chimney. All three types are illustrated. H. R. C.

GAS AND OIL ENGINES.

765. *Japy Motor.* **P. Sarrey.** (Locomotion Automobile, 9. pp. 54–56, Jan. 23, 1902.)—This is a stationary four-cycle internal-combustion engine which has been run very successfully on alcohol fuel. It has a single horizontal cylinder 14·5 cm. bore × 16 cm. stroke, water-cooled. The induction valves are automatic and the exhaust mechanically operated. The carburettor is of the float-feed spraying type, with a special arrangement of baffles for breaking up the spirit sucked out of the jet; it is mounted close up to the induction valve box. With pure commercial alcohol, 3·75 b.h.p. is developed at 300 r.p.m. on a consumption of 2 kg. 15 per hour. With 50 per cent. alcohol, 3·76 b.h.p. is developed at 300 r.p.m. on a consumption of 1 kg. 54 per hour. Several illustrations are given of this engine, and a photograph of a double-cylinder vertical engine for motor cars. C. R. D'E.

766. *Balzer Revolving Cylinder Engine.* (Horseless Age, 9. pp. 141–142, Jan. 29, 1902.)—This is a five-cylinder internal-combustion engine in which the crank-shaft is fixed and the cylinders revolve and constitute the flywheel. The cylinders are single-acting, air-cooled. They have mechanically operated inlet and exhaust valves. Electric ignition is employed. Ten h.p. is developed at 500 r.p.m., and the engine weighs 300 lbs. C. R. D'E.

767. *"Loyal" Cooler.* (Locomotion Automobile, 9. pp. 40–41, Jan. 16, 1902.)—The cooler, which is for use in motor cars, consists of a number of small tubes connected at inlet and outlet to a single large tube. Around the small tubes are mounted corrugated radiating ribs. The outline of the cooler is such that it will fit into the ordinary motor bonnet at the front of the car frame. The lengths of the compound tube required per h.p. are, with nine small tubes, 45 cm.; with thirteen tubes, 30 cm.; and with twenty tubes, 20 cm. C. R. D'E.

768. *"Electro-Catalytic" Igniter.* (Locomotion Automobile, 9. pp. 42–44, Jan. 16, 1902.)—A piece of platinum-iridium, or preferably osmium-iridium-ruthenium alloy, is mounted in a tubular metal socket which screws into the combustion chamber of the engine, like an ordinary electric sparking plug. The osmium alloy is heated by an electric current of about ½ watt, and the motor turned by hand in the usual manner for starting. The hydrocarbon vapour sucked in from the carburrettor then causes the igniter to glow brightly, and the ignitions commence. The electric current is then cut off, and the ignitions continue automatically until the engine is stopped by cutting off the mixture from the carburettor. The point of ignition can be varied by shifting the igniter within the tubular socket. This adjustment is easily effected by an external screw. The igniter is the invention of A. Wydts. C. R. D'E.

AUTOMOBILISM.[1]

769. *War Office Heavy Motor Vehicle Trials.* (Automotor Journal, 6. pp. 139–155, Jan., 1902.)—This article contains descriptions of the mechanical features of the five competing lorries, together with accounts of the performance of each vehicle throughout the trials. Detailed illustrations of the two Thornycroft steam vehicles and of the Milnes oil engine lorry are given, together with numerous photographs taken on the day of the cross-country runs. C. R. D'E.

770. *Fouillaron Light Car.* **L. Fournier.** (Locomotion Automobile, 9. pp. 22–24, Jan. 9, 1902.)—This car is constructed on the lines common to French light petrol cars. Its special feature consists of a variable speed belt transmission, employing expansible pullies, giving a V-shaped bed to the belt. The belt itself is constructed of leather blocks, which are arranged to adapt themselves to the varying inclination of the walls of the pulleys. The engine is of the single-cylinder vertical type, mounted near the front of the underframe. The variable-speed gear transmits from the countershaft to the differential shaft, and the final transmission to the road wheels are by chains. C. R. D'E.

771. *"Passe Partout" Motor Carriage.* (Locomotion Automobile, 9. pp. 38–40, Jan. 16, 1902.)—This is a light tricycle carriage, to seat two persons side by side, and partially collapsible for transport by rail. The frame is tubular, and carries towards its front end, which is built up to meet the steering pillar, a single cylinder petrol motor. The transmission is effected, first by a chain drive to a short-jointed shaft mounted on the steering pillar, and thence by chain to the front wheel, which is used for both steering and driving. A change-speed gear is mounted on an extension of the crank-shaft, between the shaft and the pinion of the first chain drive. The body is carried by light plate springs. The vehicle can be folded into a space of 135 cm. long × 70 cm. wide, and weighs about 200 kilos. C. R. D'E.

772. *"Alcohol" Postal Vans.* **L. Périssé.** (Locomotion Automobile, 9. pp. 70–71, Jan. 30, 1902.)—The vehicle described consists of a light van body for postal work, mounted on a standard Pengeot underframe and gear, fitted with a two-cylinder horizontal engine, with cylinders 80 mm. × 108 mm., and developing 4 h.p. at 760 r.p.m. All four wheels of the vehicle are of equal diameter, and have pneumatic tyres. The total weight of the vehicle loaded is 1,250 kg., of which 500 kg. is useful load; it is possible, on an emergency, to carry a load of 1,000 kg. Leprétre 50 per cent. alcohol is employed. Experience has shown that with this spirit a considerable deposit is formed in the tank and carburettor. The valves of the engine become quickly pitted, and require constant attention. From the results of many weeks' trial the consumption of alcohol works out at 0·140 lit. per tonne km., and with petrol 0·116 lit. per tonne km. C. R. D'E.

773. *Hafelfinger Motor Bicycle.* (Locomotion Automobile, 9. pp. 25–26, Jan. 9, 1902.)—In this bicycle, a single cylinder petrol motor is mounted on a diamond cycle frame of the ordinary type, except that the lower portion of the seat-post is formed of four tubes, between which is mounted the motor,

[1] Electric Automobiles are described in the Section dealing with Electric Traction.

with its crank chamber next to the bottom bracket. The crank-shaft is geared by spur wheel and pinion to a hollow shaft running on ball bearings in the bottom bracket. An equal ratio chain drive transmits from this shaft to the rear wheel of the machine. The pedal spindle runs through the hollow shaft, with which it engages by roller clutches which run free as soon as the engine starts. C. R. D'E.

774. *Aeronautical Experiments.* **W. Wright.** (West. Soc. Engin., Journ. 6. pp. 489–510, Dec., 1901.)—This paper opens with a review of the work of Lilienthal, Pilcher, and Chanute with flying-machines of the aeroplane type, depending on gravity and wind for motive power. Balancing was one of the chief difficulties encountered by these experimenters. Balancing consists simply in causing the centre of pressure to coincide with the centre of gravity. It is very difficult in practice to make these centres coincident. In the machine mentioned above, balancing was effected by the operator shifting the position of his body during flight. The machine of W. and O. Wright is of the double-dèck type, having two large cloth surfaces one above the other, attached to, and connected by, a light framework. These surfaces are slightly curved, and are approximately parallel, their width being several times greater than their depth in the direction of flight. The operator lies in a horizontal position, face downwards, on the longitudinal centre-line of the lower surface, his head being somewhat in advance of the front edge of the plane. The balancing and elevation of the machine are controlled by a third and smaller surface in advance of the machine, and so placed that the effect of the wind upon it counterbalances the pressure, due to passage through the air, on the main surfaces. This third surface can be curved up or down by the operator for steering. The lateral equilibrium and turning to right or left is effected by a torsion of the main surfaces. The machine used in experiments at Kitty Hawk, North Carolina, in 1900, had 165 square feet area. Used as a kite, it was supported with a man on it in a wind of about 25 m. per hour at an angle of 20°, this angle being much greater than had been calculated from Lilienthal's tables. Measuring the lift and drift of the machine, it was found that, while sustaining a weight of 52 lbs., the horizontal pull was only 8·5 lbs., which was about 50 per cent. less than the head resistance of Chanute's machine. Its deficiency in lifting power was attributed chiefly to insufficient curvature of the surfaces, this being only about 1 in 22, and to the fact that the cloth was not airtight. The control of the machine by means of the third surface proved entirely satisfactory. In the following year—1901—an almost identical machine was used, but the superficial area was increased to 308 square feet, and the curvature of the surfaces was 1 in 12. At first, certain difficulties were experienced in controlling this machine, but these were overcome by reducing the depth of curvature of the surface. Glides of over 300 feet at an angle of descent of 10 degrees were safely made. The fact that the surfaces were not perfectly airtight was found not to have any appreciable effect on the carrying capacity of the machine. The chief conclusions arrived at were: (*a*) That the Smeaton coefficient of $0{\cdot}0005V^2$ for the wind pressure at 90° is probably 20 per cent. too great; (*b*) that Lilienthal's estimate, that the pressure on a curved surface having an angle of incidence of 3° equals 0·545 of the pressure at 90°, is perhaps 50 per cent. too great; (*c*) that the superposition of surfaces somewhat reduces the lifting power per square foot. The paper is illustrated by photographs of the machines in flight. C. R. D'E.

GENERAL ELECTRICAL ENGINEERING.

775. *Wright Electrolytic Meter.* **J. R. Dick.** (Inst. Elect. Engin., Journ. 31. pp. 95–116, Dec., 1901.)—The author reviews briefly the earlier types of electrolytic meters; those depending on the deposition of mercury have the advantage of a very low back e.m.f., and of affording indications by volume instead of by weight. Difficulties are encountered in the deposition of crystals at the anode, variation in the resistance of the meter, and in contamination of the mercury. In Wright's meter a large vertical glass tube is closed below, and terminates above in a bulb. A trough is formed at the junction of tube and bulb, and contains the mercury which forms the anode. An auxiliary bulb containing mercury, and connected with the trough, acts like a bird fountain in maintaining the level of mercury in the trough. The kathode is a hollow cone of platinum or carbon, situated in the tube just below the mercury trough. By thus arranging the kathode below the anode, the formation of crystals is avoided, as the solution near the anode descends by gravity as soon as it becomes more concentrated. The meter is hermetically sealed, and is filled with a solution of mercurous nitrate. The mercury deposited in the kathode drops from it into a graduated tube, from the bottom of which rises an inverted U-tube; this acts as a syphon as soon as the graduated tube is filled, and the contents are emptied into a second graduated tube below. The syphon tube contains mercury representing 100 units, and each division in it represents one unit; the lower tube is graduated in hundreds of units, and corresponds to a second dial in an indicating train. The 5-ampere meter registers up to 12,000 units, and when a full record is obtained, the meter is reset by tilting it and allowing the mercury to flow back into the bulb. The meter is connected in shunt to a platinoid resistance in the main circuit. This has a value giving a drop of 1 volt on a 200-volt supply at full load. In series with the meter is a resistance partly of platinoid and partly of copper wire; the copper-wire resistance is adjusted to compensate for the negative temperature coefficient of the electrolyte. Tests made on the meter show that an accuracy of within 1 per cent. is easily obtained commercially, from very small currents to full current. The meter can be combined with a maximum demand indicator in such a way that the heating resistance of the latter forms the shunting resistance of the former, and the total drop of pressure is thus limited to 1 volt.

G. H. B.

776. *Electrical Equipment of Cranes.* **W. Rung.** (Elect. Rev. 49. pp. 411–412, Sept. 6; 499–500, Sept. 27; 621–622, Oct. 18; and pp. 903–905, Nov. 29, 1901.)—The direct-current series-wound motor is well suited for cranes. It has great starting torque, and starts smoothly; it lifts a heavy load slowly and a light one quickly; but it is unsuitable in cases where the load is liable to be very small, as the speed may then become so high as to be dangerous. The shunt motor is mainly used in cases where a constant speed is desired. The polyphase motor is as good as a direct-current motor; its starting torque can be made as great as that of a series-wound motor, and its speed can never exceed the normal. In any case the motor must start smoothly with a small amount of current, and must stop as quickly as possible when the current is switched off. It should therefore have a small amount of inertia, and run at

a low speed. In the case of a 50-h.p. motor, running at 550 r.p.m., the armature weighed 500 kg., with a diameter of 36 cm.; another motor, also of 50 h.p., running at 200 r.p.m., had an armature weighing 800 kg., with a diameter of 56 cm. Upon calculating the moments of inertia it was found that the former required 2·9 times as much power at the start as the latter. As for three-phase motors, sizes up to 4 or 5 h.p. can be made with squirrel-cage rotors, and require no starting resistance, but they have relatively small starting torque, and start suddenly. Brown, Boveri & Co. build such motors with rotors of large electrical resistance; this increases the starting torque, and provides a smooth start. The brake action, caused by changing the motor into a generator, does not necessarily bring the armature to rest. If the braking is attempted after the speed has fallen below a certain limit, the e.m.f. of the motor may be so small as to cause no braking action, and in any case this method does not enable the load to be held in any position. Some form of mechanical friction brake is almost always added. An iron or copper disc rotated in a magnetic field will produce a braking action owing to eddy currents, but this action ceases as soon as the speed falls below a certain limit. The positions of the motors on the crane are then discussed, and a drawing is given showing the most suitable arrangement of motors and the wiring for a three-phase crane. The motor for working the crane longitudinally is best placed at the middle of one of the girders. The other motors should be carried by the crab. Any arrangement by which a motor is placed at the end of one of the girders is undesirable, although it shortens the electrical connections. Spur-wheel gearing is to be preferred to worm-wheel gears on the ground of efficiency. W. H. S.

777. *Electric Feed-pumps.* **A. Johnston.** (Elect. Rev. 50. pp. 43–44, Jan. 10, 1902.)—The main problem in connection with electric feed-pumps is the regulation of the amount of water pumped into the boilers. One method is to close, or partially close, the check valves; the pump is run at constant speed, and is fitted with a relief valve, which is set to open at 20 or 25 per cent. above the working pressure of the boiler, the surplus water being returned to the hot well. Another method is to insert a resistance in series with the motor, which reduces the voltage across the motor terminals; the current will, however, be practically constant at all speeds. Neither of these methods can be regarded as economical. The best method is probably that using the series-parallel control, the motor armature having two separate and similar windings, each connected to a separate commutator. The author gives a list showing the various combinations possible, supposing the motor to be series-wound and the field to be divided into two equal sections. He is in favour of direct-coupled pumps without gearing, the pumps being smaller than usual, and the motors larger. In some correspondence which took place in the two succeeding issues of the Electrical Review, Mather and Platt state that they construct a feed-pump in which the delivery is controlled by varying the length of the stroke of the pump; and Merryweathers state that they construct a direct-connected pump, and give some figures which show the results obtained from one of their pumps erected in the Bristol electricity works. W. H. S.

REFERENCE.

778. *Electrical Drilling Machines.* (Engineer, 92. p. 634, Dec. 20, 1901.)—An illustrated description of several types of portable radial drills. H. R. C.

GENERATORS, MOTORS, AND TRANSFORMERS.

779. *A Three-phase Alternator.* **F. Winawer.** (Elekt. Runds. 19. pp. 86–87, Jan. 15, 1902.)—The article describes, with illustration, a new three-phase flywheel alternator, constructed by the Electrical Industry Company of Carlsruhe, wound for 4,000 volts, for coupling direct to a 760-h.p. engine running at 91 r.p.m. The armature ring is a massive cast-iron casting, which, when bolted up, is roughly triangular in cross-section. The diameter over the poles (66), which are bolted on to the rim of a double-armed flywheel, is 5·3 metres. The steam consumption of the set is given as 8·8 kg. per kw.-hour. E. K. S.

780. *Hunting of Paralleled Machines.* **A. Föppl.** (Elektrotechn. Zeitschr. 23. pp. 59–64, Jan. 23, 1902.)—Referring to Kapp's article on this subject [see Abstract No. 1085 (1899)], the author, while expressing himself in agreement with the general theory developed by Kapp, differs from him as regards the cause of the "hunting" or "phase-swinging." According to Kapp, this phenomenon is due to resonance effects between the driving torque of the engine and the natural oscillations of the alternator armature. The author points out that if such were the case, the oscillations would, according to a numerical example given by Kapp, be extremely rapid, while the period of the hunting of an alternator is relatively slow. The cause of the phenomenon is to be looked for in the behaviour of the governor of the engine, and this the author proceeds to investigate in detail, taking a Porter governor as the standard case. The conditions under which hunting of such a governor takes place are deduced from a simplified differential equation expressing the general relation between the various forces which act on the governor. Three cases are considered: (1) a single engine; (2) two engines rigidly coupled to the same shaft; (3) two engines connected to the same shaft through *elastic* couplings. The latter case corresponds precisely to engines driving paralleled alternators. The author deduces a formula by means of which the conditions under which no hunting can take place may be deduced, in terms of the constants of the governor and the torsional constant of the elastic couplings, and expresses a hope that an effort may be made to obtain an experimental verification of his theoretical deductions. A. H.

781. *Mechanical Slip Counter for Asynchronous Motors.* **E. Ziehl.** (Elektrotechn. Zeitschr. 22. pp. 1026–1028, Dec. 12, 1901.)—With the help of two coupled speed counters it is shown how the relative velocity between the rotor of a motor and the synchronous speed may be accurately found. The usual procedure will be to drive from the source of supply a small synchronous motor, and connect its axis, by means of a flexible coupling, to one of the counters, the other one being pressed into the centre of the shaft of the motor under experiment, when the slip per minute may be directly read off. The apparatus is made by the Berliner Maschinenbau-A-G. W. W. H. G.

782. *Discussion on Motors and Meters.* (Amer. Inst. Elect. Engin., Trans. 18. pp. 857–882, Dec., 1901.)—**Steinmetz,** referring to Browne's paper [see Abstract No. 2388 (1901)], considered that the consumers should pay some-

thing for the wattless current taken by their induction motors. Motors could be obtained taking small wattless currents at starting, but were more expensive ; consumers would therefore purchase them only if their bills for current were diminished thereby. He mentioned a case where meters were made to register 25 per cent. of the wattless current by introducing self-induction into the shunt circuit. **Buck,** referring to Lincoln's synchronism indicator [see Abstact No. 1943 (1901)], pointed out that the need of an accurate apparatus of this description was increasing, for, with the large direct-coupled alternators now coming into use, the power required to synchronise the machine is very large. **Mershon** and **Scott** pointed out that an induction motor takes an excessive wattless current at starting, only if it has a short-circuited rotor ; if provided with slip-rings and an adjustable resistance it will compare favourably with a direct-current motor. **Mailloux** mentioned a case where a 40-h.p. induction motor took so much wattless current at starting as to frequently blow the fuse of a 150-kw. machine ; he considered that a consumer using motors of this description should be penalised by a charge for wattless current. **Dunn** showed curves of 5-h.p. shunt and compound direct-current motors and an induction motor. From these he concludes that the induction motor takes 10 per cent. more power at full load, and twice as much starting current for the same torque. At partial loads the efficiencies are about the same, but at full load that of the induction motor is some 3 per cent. less. The increase in speed between full and no-load is 4½ per cent. for the shunt, 6 per cent. for the induction, and 7½ per cent. for the compound motor. The maximum torque which can be obtained from the induction motor is 2·7 times the normal, from the shunt motor 6·4 times, and from the compound 10·8 times the normal torque. G. H. B.

783. *Alternate-current Motors and Rotary Converters.* **C. F. Scott.** (Amer. Inst: Elect. Engin., Trans. 18. pp. 883–894, Dec., 1901.)—The author enumerates the characteristics of synchronous and induction motors in parallel columns. The comparison shows that the former is not suitable for general distribution of power, owing chiefly to its lack of starting torque, the skill required in attendance, and its liability to stop if the conditions become abnormal. These objections are less important when motors are installed in substations or are of sufficient size to justify an attendant ; and the synchronous motor possesses the advantage of giving a means of bringing the power-factor of the circuit to unity. The rotary converter is essentially a synchronous motor, and is subject to many of its defects. The starting, however, is simpler, and no exciter is required. The author compares the rotary converter with an induction motor generator ; wherever the generators are subject to fluctuations in speed, the latter are preferable. G. H. B.

784. *Geometrical Study of the Alternating-Current Transformer.* **Brunhes.** (Assoc. Ing. Él. Liège, Bull. 1. pp. 399–447, Nov.–Dec., 1901.)—Problems in connection with the alternating-current transformer are solved geometrically. Instead of starting with the assumption that the applied p.d. is constant, the author supposes that the resultant of the magnetising forces is constant. He then constructs a diagram showing how the pressures can vary subject to this restriction. From this diagram the values of the magnetising forces when the applied pressure is constant can be found by constructing inverse curves. The geometrical properties of these inverse curves are fully discussed and the results applied to solve transformer problems, taking hysteresis, eddy currents, and inductive loads into account. A. R.

785. *Cooling of Transformers.* **W. S. Sessions.** (Journal of Electricity, S.F., 11. pp. 264–265, Nov., 1901.)—It was found at the power station of the Mount Whitney Power Company [see Abstract No. 375 (1900)] that the 500-kw. transformers used to raise the generation voltage from 440 to 17,300, although built with a large radiating surface, and air cooled, became overheated in the summer. The oil in the transformers was therefore pumped through long coils of iron pipe placed in the tail race, and then returned to the transformers. The pump was started on June 3, 1901, stopped from the 9th to the 14th, and then kept running continuously. The results are given in the following table ;—

A Comparison of Air and Transformer Temperatures.

(Readings taken daily at 6 p.m.)

Day of Month.	Month of May. Temp. deg. Fahr.		Month of June. Temp. deg. Fahr.		Month of July. Temp deg. Fahr.		Month of Aug. Temp. deg. Fahr.	
	Air.	Oil.	Air.	Oil.	Air.	Oil.	Air.	Oil.
1	76°	115°	94°	130°	100°	86°	106°	104°
2	76	108	89	121	98	90	105	105
3	80	117	88	84	91	88	100	107
4	84	117	85	76	95	97	95	108
5	85	117	90	76	104	97	98	115
6	88	122	91	83	107	90	102	116
7	88	124	91	83	101	88	104	116
8	90	126	84	76	99	90	103	116
9	90	125	83	112	100	90	105	117
10	93	126	82	118	104	90	106	117
11	87	113	85	120	104	92	104	108
12	89	121	82	118	103	92	108	109
13	89	121	81	117	98	90	102	109
14	90	124	88	122	96	88	100	108
15	90	124	95	77	98	90	99	109
16	92	126	95	84	95	94	102	109
17	88	122	96	88	100	94	103	109
18	80	118	92	84	102	95	99	109
19	73	115	85	81	105	95	97	112
20	80	110	92	82	106	97	99	112
21	77	112	98	84	96	97	96	113
22	83	117	99	88	102	97	93	112
23	75	110	89	83	102	96	93	103
24	70	110	85	84	104	99	92	110
25	68	106	85	84	106	100	96	95
26	80	108	92	84	108	101	98	109
27	78	112	99	88	106	101	98	110
28	79	111	105	88	104	100	97	108
29	87	118	109	88	97	102	97	106
30	85	121	103	86	98	102	95	106
31	93	124	...	...	106	106	93	105

The variation in the temperature difference between the oil and the transformer when the pump was running is partly due to change in the water temperature with the season, but mostly to variation in the load, which was extremely heavy during August. G. W. de T.

786. *Core Transformers of Maximum Efficiency.* **F. Punga.** (Zeitschr. Elektrotechn., Wien, 19. pp. 609–614, Dec. 15, and pp. 624–625, Dec. 22, 1901.)—The author considers in detail the following two problems: (1) Given the complete specification of a transformer, to determine the dimensions of the core corresponding to minimum cost of materials; (2) given the cost, to construct the transformer so as to satisfy the condition of maximum efficiency. In either case the author supposes the core to be □-shaped, with cylindrical coils on the vertical limbs of the core, the cross-section of which is assumed to be a square. The method of solution consists in assuming that the length of core and depth of winding are made to undergo a small change, and investigating how this change affects total cost in the first case, and efficiency in the second. The results obtained involve the relative cost of copper and iron, and the ratio of the actual cross-section of copper to the total cross-section of the coil. The author gives a number of curves embodying the results of his calculations. A. H.

787. *Rotary Converters.* **A. S. M'Allister.** (Amer. Electn. 13. pp. 568–570, Dec., 1901.)—This paper is a *résumé* of the principles of construction and working of rotaries. The following are some of the points discussed:—Speeds and frequencies; the ratio between the direct and alternating voltages for different ways of connecting; wave-form; field excitation; pendulum motion of armature; methods of starting and synchronising. The advantages of rotaries over direct-current generators are insisted on, and the causes explained; absence of field distortion and increased output in the rotary due to diminution of effective armature resistance being specially alluded to. In connection with this latter point, the author urges the desirability of using six-phase rotaries, from which a much greater output can be obtained than from three-phasers; the six-phase current can be obtained from an ordinary three-phase supply, the connections being in reality not at all complicated. The paper concludes with a discussion of the "inverted" use of rotaries, as operated to convert from direct to alternating current. B. P. S.

788. *Transformers in Parallel.* **A. G. Hansard.** (Electrical Times, 21. pp. 86–87, Jan. 16, 1902.)—A simple explanation is given of the parallel working of the alternating-current transformer. To insure good parallel working it is not sufficient to specify that the transformers have the same transformation ratio and the same drop from no-load to full load. The author points out the importance of measuring the "short-circuit volts" of a transformer, which can easily be done by short-circuiting one winding through an ammeter, and applying to the other winding a p.d. that will cause the full-load current to be read on the ammeter. If transformers of different designs are to be run in parallel it is absolutely necessary to specify the "short-circuit volts." A. R.

789. *Hutin and Leblanc's Improved Rectifier.* **A. Vincent.** (Écl. Électr. 30. pp. 29–38, Jan. 4, 1902.)—This is the first instalment of a paper descriptive of the new type of "Panchahuteur" [see Abstract No. 356 (1900)], in which the primary of the transformer creates a revolving field, which produces an e.m.f. in the successive windings of the secondary, of which the values vary from coil to coil exactly like the pressures in successive armature coils of an ordinary bipolar dynamo. As in the former type of "panchahuteur," connections are brought out from each secondary to the bars of a fixed commutator, round which the brushes are rotated in synchronism with the speed of the

revolving field. A description is given, illustrated by wood blocks and photographs, of the fixed transformer, and of the brush motor. A special feature of the former is the system of compensating coils adopted to ensure that the revolving field should have a constant strength and a sinusoidal distribution around the ring. It is shown mathematically that the number of turns in these compensating coils (of which there are two sets, a primary and secondary) should vary from coil to coil according to the sine law. In the mathematical treatment of the subject, an alternating flux is looked upon as the resultant of two constant fluxes rotating in opposite directions at a uniform speed. If, then, the primary of the transformer be supplied with a monophase alternating current, one of the rotary fluxes which may be considered to be generated thereby—that, namely, which turns in the same direction as the brushes—constitutes the useful field; the other is a harmful field, which would produce in the coil, which at any instant is short-circuited by the brush, an electromotive force which would waste energy and produce sparking; and this flux must be neutralised if commutation is to be perfect. In the case of a transformer supplied with a system of polyphase currents, producing a single rotary field, the system of compensating coils by ensuring a harmonic distribution of the main flux reduces the harmless fluxes to a negligible point. B. P. S.

790. *Hutin and Leblanc's Improved Rectifier.* **A. Vincent.** (Écl. Électr. 30. pp. 55–61, Jan. 11 1902.)—This is a continuation of a former paper [see preceding Abstract]. The author now discusses the action of his machine when transforming from direct to alternating current; the first case considered is from low-tension direct to high-tension polyphase. The fields of the brush motor are first excited, and the machine started up by a hand-gear, which is automatically disconnected when the proper speed is attained. At the same time the brushes are pressed against the collector by the action of centrifugal force. Continuous current is then sent through the thick-wire winding of the transformer, being regulated by a starting resistance. A rotary magnetic field is thus produced in the transformer, revolving with the same speed and in the same direction as the brushes. The author proceeds to explain the effect of the "compensating coils" in making the flux truly sinoidal. The final result in the rotating armature being a flux fixed in space, there can be drawn from its windings an alternating current of any desired number of phases, depending on the number and positions of the points where the armature winding is tapped. The frequency of the two- or three-phased currents drawn from the armature depends on the speed of the motor, and this can be regulated with great nicety by controlling the pressure at the direct-current terminals. As in an ordinary direct-current motor, the lead of the brushes for good commutation must vary with the load; this is effected in the present case, not by any adjustment of the revolving brushes, which would be a difficult matter, but by rotating the fields of the brush motor through the desired angle by a mechanism provided for the purpose. In the special case where single-phase current is drawn from the armature by tapping at the extremities of a diameter, the inventor finds it necessary to make use of a small auxiliary two-phase motor, provided with an "amortisseur," which is connected in circuit with the "resultant circuits" of the transformer, with which it runs synchronously. This has the effect of neutralising the harmful component of the revolving magnetic field referred to in the former part of the paper. This auxiliary motor is mechanically quite independent of the transformer, and can be fixed in any convenient position.

In addition to the function alluded to, it plays another important part, similar to that performed by a flywheel in the analogous case of the mechanical conversion of a periodic straight line movement into uniform circular motion; the input of energy into the transformer (in the shape of continuous current) being uniform, and the output, when in the form of *single-phase* alternating current, essentially oscillatory, the motor stores up and restores to the circuit at the right instant the energy which would otherwise be used very inefficiently.

The paper concludes with a description of some very successful tests made on the machine operating in various ways, and with a summary of its advantages and uses. These may be thus stated: (*a*) If supplied exclusively with direct current at low tension, the machine can supply, *at the same time*, mechanical energy available at the motor pulley, and electrical energy, under the form of high-tension alternating current. (*b*) Conversely, if supplied with high-tension alternating current, both mechanical energy and low-tension continuous current can be obtained from it simultaneously. (*c*) If only mechanical energy is required, the machine can be supplied with low-tension continuous current and high-tension alternating at the same time. (*d*) If the machine is fed with "resultant currents" drawn from the motor acting as generator, it becomes a two-current generator, and can furnish at will, or simultaneously, low-tension direct current and high-tension alternating. Points worthy of notice are: that the commutation is perfect at all loads, and that the output is therefore limited simply by the heating of the coils; and that owing to the suppression of all the more important harmonics (in the machine described the fifty-ninth harmonic is the first which is allowed to develope) the wave form of the alternating current produced is practically a perfect sine-curve. B. P. S.

REFERENCE.

791. *Rotary Converters.* **G. W. Colles.** (Frank. Inst., Journ. 151. pp. 207–235; 263–282; 341–368; 429–445; and 152. pp. 12–26, 1901.)—This series of articles gives a very exhaustive and up-to-date account of the various forms of apparatus which have been devised for the purpose of transforming one form of electric current into another, and which contain rotating parts. The historical aspect of the problem of transformation is very fully dealt with, and the articles are fully illustrated.

A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

792. *Effect of Bending of Poles on the Tension of a Broken Line.* **Colard.** (Assoc. Ing. Él. Liège, Bull. 1. pp. 338–349; Discussion, pp. 349–350, Aug., Sept., and Oct., 1901.)—If a breakage occurs in an aerial line, the bending of the poles will give rise to an increased sag, and corresponding diminution of tension, which increases as the broken section is approached. The author confines his attention to cases in which the sag is small enough to permit of the identification of the curve assumed by the wire with the ordinary parabola. In a former paper (La Lumière Electrique, 52. p. 557, June 23, 1894), he gave an analytical method of solving the problems arising, by means of expansions in series. The series obtained were not, however, convenient for calculation, and in the present paper he sets forth a graphical trial and error method which he finds simple and easily applicable in practice. The most important problem is to so determine the strength of the poles as to ensure their withstanding the greatest lateral pull to which they may be subjected by the breaking of the line, while avoiding the unnecessarily high cost which would be involved if provision were made against a lateral pull equal to the tension of the unbroken line. G. W. DE T.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

793. *The Boston, U.S.A., Subway and the Rapid Transit Subway, New York.* (London County Council Report, No. 555, pp. 3–19, Nov. 7, 1901; also Tram. Rly. World, 10. pp. 709–712, Dec., 1901. Abstract.)—Both these schemes were entered upon on the reports and suggestions of Commissions appointed by the local authorities in the respective towns; in the case of Boston the Commissioners visited, as a preliminary step, numerous European cities for the purpose of comparing the various methods adopted for the relief of street traffic congestion. The Boston tramway will, when complete, be equivalent to 5 miles of single track, part being laid with four tracks and part with two. That portion now completed is 1,300 yards in length, and commences with an incline 100 yards in length, carrying the surface lines underground. In streets where ample space existed the method of open excavation was adopted, tunneling proper being resorted to for one or two short lengths where cut-and-cover methods were not practicable. There are three distinct types of subway: (1) the side walls and arch are of masonry; (2) two distinct masonry tunnels, side by side; (3) transverse steel girders and jack arching to form the roof, supported by side walls composed of steel columns interspersed with masonry or concrete. The open inclines leading to the tunnel have granite walls, and are protected by railings. The standard height of the roof is 14 feet clear above the surface of the rails, and the roof is generally about 3 feet below the street surface. Lifts are thus unnecessary, approach to stations being gained by a short, well-lighted stairway. The island principle has been adhered to in the platforms and separate entrances and exits provided. Glazed brick lining is used only near the stations, the remaining lengths being simply whitewashed. Both the overhead trolley and third-rail systems are employed. The tunnel is lighted throughout by incandescent lamps, although a considerable amount of natural light is

obtained. The number of cars running in each direction is 250 per hour, the passenger traffic at the busiest station being stated at 27,400,000 per annum. In the opinion of the L.C.C. Commission the effect of the subway upon the street traffic has been very considerable.

New York.—The subway here is at present under construction, and will consist of a total length of 21 miles, seven of which are to be laid with four tracks and 14 miles with double tracks. Cut-and-cover methods are adopted, the covered way being rectangular in shape and built in open trench. Transverse steel frames, supported on concrete bottoms, are placed at 5-feet intervals with concrete walls and roof, the concrete enclosing the steel entirely. Light steel columns between the tracks afford a further support to the roof. The two centre tracks will be used for an express service, designed for a speed of 30 miles an hour, with stations 1½ miles apart. On the outer tracks 14 miles an hour is the designed speed, with stations at more frequent intervals. Crossings and switches are reduced to a minimum by lowering one track under the other. The work will be completed in 1904.

The L.C.C. Commission favour the plan of shallow underground tramways for London as a means of (1) linking up existing tramways by taking surface cars through congested and prohibited areas, (2) affording provision for pipes, cable wires, &c., thus obviating the continual breaking up of the streets.

C. E. A.

794. *Truckee River Electric Power Plant.* (Eng. Record, 44. pp. 562–563, Dec. 14, 1901.)—This paper contains a description of a water-power station, transmitting power by three-phase current over a distance of 30 miles to the Comstock silver mines in California. W. H. S.

795. *Power Station at Ludlow, Mass.* (Eng. Record, 44. pp. 610–613, Dec. 28, 1901.)—The Ludlow Manufacturing Company has built a water-power station at Red Bridge, on the Chicopee River, where 5,000 h.p. is generated and transmitted by three-phase current over a distance of four miles to the Company's hemp and jute factories. The article is mainly concerned with a description of the hydraulic work. W. H. S.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

796. *Polyphase Currents for Traction Work.* **I. Galmozzi.** (Assoc. Ing. Él. Liège, Bull. 1. pp. 351–396, Aug., Sept., and Oct., 1901.)—In this paper the author developes, simply and systematically, the systems of equations applicable to the case of a trolley line supplied with either two-phase or three-phase currents. A numerical example of a three-phase system is worked out in detail. The author advocates a two-phase in preference to a three-phase system, mainly on account of its greater economy, resulting from the fact that for a given frequency and a given amount of power delivered to the motors the current in the trolley wires will be less, and that in the rails greater, in a two-phase then in a three-phase system, with a consequent saving in C^2R losses, owing to the very much higher conductivity of the rails as compared with the trolley wires. He shows that under the conditions ruling in practice the additional lag due to the permeability of the rails is not sufficient to cause serious inconvenience. G. W. DE T.

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

797. *A High-Speed Railway Car.* **O. Lasche.** (Inst. Elect. Engin., Journ. 31. pp. 24–66 ; Discussion, pp. 66–76, Dec., 1901.)—This car has been arrived at after protracted experimental investigation resulting in numerous modifications, by the Allgemeine Electricitäts Gesellschaft, working in co-operation with the German "Association for the Study of Electrical High-Speed Railways," and will be tried on the military line from Berlin to Zossen, at speeds varying up to a maximum, as at present intended, of 200 kilometres (124 miles) an hour. The power will be supplied from the Oberspree Central Station, 15 kilometres (9·3 miles) from the nearest point of the line, with three-phase current at 50 ∿ , and a voltage of from 10,000 to 12,000. The voltage will be reduced to 435 by the transformers in the car. About 50,000 is regarded as a suitable voltage for main railway lines, and the author suggests the possibility of its being found advisable to transform this down to 3,000 at substations along the line, winding the motors for the latter voltage, and so eliminating the heavy weight of the transformers from the car equipment. Transformation to continuous current he regards as impracticable for long-distance railways, as it would involve the use of rotary transformers, at very short intervals on account of the low voltage limits, with attendance at all substations. The inconvenience of the three trolley wires for points and crossings might require the use of a slow-speed continuous-current locomotive to take cars over sections traversing large towns.

Car Body.—The car is 21 m. (69 ft.) long by 2·6 m. (8 ft. 6 in.) broad, with a distance of 23·1 m. (72½ ft.) between the buffer plates, and carries 50 passengers. The windows are closed, ventilation being effected by means of the side windows of the skylights. The apparatus is in the centre of the car, and this portion, as well as the driver's platform, has grated doors to exclude the passengers, who can, however, pass from one compartment to the other. No live conductors are accessible to either driver or passengers. The front of the car is slightly curved, but the best shape is left for experimental determination by the addition of various shaped screens during the trials. *Bogies.*—The two bogies are 13·3 m. (43 ft. 7 in.) apart, each having three axles, of which the two outer ones carry the motors; the middle one having no motor, space is left for the pivot and the Westinghouse brake cylinders. The diameter of the wheels is 1,250 mm. (49·2 in.), and the distance between them is 3,800 mm. (12 ft. 6 in.). There are no springs bearing against the body of the car, but the bogies themselves are supported on the axles by two sets of springs ; and each axle-box carries a strong plate spring, to the head of which are attached supporting springs carrying the frame. *Current Collection.*—The trolleys are of the bow type, three at each end of the car, each trolley being carried on a separate arm. In order to avoid any material change of distance from the trolley wires when passing curves, the distances between the arms are only just sufficient to allow of the bows turning about the vertical axes. To ensure good and continuous contact at high speed without large contact surface, each bow is formed of a number of aluminium contact rods carried by plate springs of different lengths. The head of the arm carrying the bow is pressed out of aluminium sheet, and is connected to the vertical base by rods, the base being mounted on ball bearings in the socket on the car. The bow is pressed against the trolley wire by springs, the tension of which is regulated by cams. All high-pressure conductors were tested to 20,000 volts, and in addition are mounted on high-pressure insulators. Safety fuses are fixed close to each bow, and the leads pass from them to a high-pressure switch to cut off current at the termini, but which will not be used while running, unless in case of failure of the con-

troller switches through any accident. Fuses are inserted between the high-pressure switch and the transformers. *Transformers.*—The secondary consists of a massive copper spiral, separated from the primary by a micanite cylinder. The axes of the cores are placed longitudinally in the car, and a cooling air current entering through the roof is first filtered, and then flows through longitudinal channels provided in the interior of the cores, but does not come in contact with live conductors. The cores are supported at their centres to prevent deformation from vibration, and the transformers are suspended from the body of the car by means of draw bolts. *Motors.*—Each of the four motors has a normal output of 250 h.p., but is capable of a maximum of 750 h.p. The speed is about 960 r.p.m, corresponding to a car-speed of 225 km. (140 miles) an hour. To ensure permanent safety in working there is only one bar in each groove, the insulation being of closed micanite tubing. The low voltage of 435 was adopted to enable a bifurcated winding to be used, and this is employed for both stator and rotor. For convenience in the arrangement of the starting apparatus and leads, the rotor is wound for only two phases. The stator, by means of two bearings, carries a hollow shaft on which the rotor is built up, and the upper half of one of these carries the brush holders, with the connections between the rotor circuit and the controller. Through the other bearing pass the stator circuit cables. Access to the brush gear is obtained by removing the lower halves of the bearings and taking out the brasses. The motors are supported by strong springs bearing against the axle box. By means of an adjustable curved block the flexure is made easy for the first few millimetres, with a gradually increasing stiffness to a maximum deflection of 8–10 mm. The motors are screwed to iron frames supported by ordinary car springs, and lateral motion is prevented by abutments bearing against slides. The stator is prevented from turning by bars which only allow of a vertical movement. The coupling is effected by means of a ring in three parts mounted at each end of the hollow shaft, double arms formed of bundles of springs being fitted in each part, the ends of the springs bearing against guide-pieces attached to the wheel. Lubrication under pressure would lead to cumbersome pipe connections, and therefore, oiling rings being unsuitable for railway work, a smooth disc of large diameter mounted concentrically on the axle, and dipping 30–40 mm. into an oil bath is employed. The bearings are of white metal, and the hollow shaft is of nickel steel. The radial distance between the latter and the axle is 30 mm. Copper rings are forced into the ends of the hollow shaft, and lateral motion of the latter is prevented by means of a guide against one bearing only, to avoid the possibility of binding when heated. The springs are secured in the annular pieces by wedges in such a manner that the centrifugal pressure increases that of the wedges. The plates are prevented from flying out by lateral extensions within the hub. The hub portions are of forged steel, and the power is transmitted by means of keys from the hollow shaft to the three-part hub of the coupling. *Controller.*—This consists of an adjustable liquid resistance, in which a small centrifugal pump, driven by an electro motor, raises the liquid from a reservoir into the resistance vessel, the resistance diminishing as the level of the liquid rises. The liquid returns to the reservoir through a number of serpentine copper tubes of small diameter in order to cool it before returning it into use. A constant circulation is maintained, so that any suitable large resistance may be brought permanently into the circuit, and the speed thereby slowed down to any extent required. An adjustable valve regulates the speed of delivery, and any desired maximum may be fixed for this, so that the driver

cannot accelerate beyond a determined rate, while retaining full control up to this limit. The power required being very small, this device can be operated from the driving platform by means of a hand-wheel and connecting shaft. *Brakes.*—A Westinghouse compressed-air brake is employed, together with two electrical methods : (1) After the rotor circuit is broken by opening the outlet valve of the liquid controller, the field circuit is, by means of a change-over switch, first broken, and then switched on to a storage battery ; (2) two of the phases bringing current to the motor are interchanged, producing a torque tending to reverse the rotation of the rotor. It is intended to employ the motor braking exclusively when running, and only to employ the air brake at the termini. [Presumably also in the case of emergencies.] The paper gives an interesting account of the experimental evolution of the designs adopted, and is copiously illustrated.

G. W. DE T.

798. *System of Rail-Joints.* (Tram. Rly. World, 10. pp. 624–625. Nov. 1901.) —This system is in use at Linz on the Danube, where it is employed on the electric street and mountain railway. The rail-coupling is constructed without screws, on the well-known wedge principle, and grasps the base of the rail at the joint, for which reason it has been designated the "rail shoe." It can be used either alone or in combination with a fish-joint, and with its use it is impossible for either rail end to be depressed, the unpleasant jolting which is so injurious to the rail-ends being thus eliminated. The joint can be put down by four men with the aid of very few tools and a portable blast-furnace. Both the placing and moving can be effected with ease. It makes a reliable electrical contact, although it is not as yet recommended that the usual copper contact-pieces be dispensed with. Besides having the advantage of a low price, it is claimed that its cost is less than one-half of that involved in casting round or welding the rail. The joints form strong supports, owing to their broad bases, increasing the stability of the whole line. Explanatory diagrams are given.

C. E. A.

ELECTRIC LAMPS AND LIGHTING.

799. *Vapour Lamps.* **P. C. Hewitt.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 935–941, Dec., 1901.)—The author has made lamps giving from 10 to 3,000 candles, with efficiencies as high as ¼ watt per spherical c.p. The mercury vapour lamp gives a light deficient in red rays ; lamps have been made giving a redder light, but at the sacrifice of efficiency. The resistance of the lamp varies inversely as the diameter of the tube, and inversely as the current. When the vapour density is increased the resistance diminishes to a minimum and then increases with the density. When current begins to pass through the lamp the resistance diminishes rapidly. The high initial resistance occurs at the negative electrode, and is diminished by positively charging the surface of the lamp exterior to the negative electrode. It is overcome by a discharge of high potential. [See also Abstract No. 622 (1902).]

G. H. B.

REFERENCE.

800. *Street Illumination.* **W. d'A. Ryan.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 909–921, Dec., 1901.)—This paper covers similar ground to that of Abstract No. 257 (1902).

C. K. F.

TELEGRAPHY AND TELEPHONY.

801. *Wireless Telegraphy.* **Ferrié.** (Soc. Int. Élect., Bull. 2. pp. 9–49, Jan.; Discussion, pp. 85–103, Feb., 1902.)—This paper deals historically with the progress of wireless telegraphy since the year 1900, when a joint report by the author and Blondel was presented to the International Congress of Electricians [see Abstract No. 477 (1901)]. At the conclusion of the historical sketch the author observes that wireless telegraphy is still subject to two serious drawbacks: (1) The complexity, cost, and delicacy of the apparatus required; (2) insecurity of communication. The latter is the more important, and is not remedied by syntonising. Transmission of messages between two points can be made impossible by operations carried on with that intent at a station between them; and, again, communication is often interrupted by atmospheric disturbances. The author commits himself to the prophecy that the telegraphic efficiency will always be low on account of disturbing causes and of slowness of transmission, both of which defects he considers to be inherent. For this reason, and on account of the increasing difficulties to be apprehended from interference between different stations as the use of wireless telegraphy extends, the author considers that its usefulness will be mainly restricted to naval purposes, though it may possibly find use in special cases in the mercantile marine and in military operations.

Discussion.—**G. Claude** spoke at length in favour of the theory that the action of the antennæ depended mainly on their electrostatic capacity relatively to the earth and to each other. The author of the paper, in his reply, showed that this theory, which had been put forward by Anderson in 1898, was inconsistent with numerous well-ascertained results of observation.

G. W. DE T.

802. *Overhead Insulators for Telephones and Telegraphs.* **E. Piérard.** (Soc. Belge Élect., Bull. 18. pp. 263–267; Discussion, pp. 267–269, July, 1901.)—Dimensioned drawings of the porcelain insulators used by the Belgium Administration are given. Where malicious damage is feared, the outer surface is not glazed, and a steel hood is cemented to the insulator with plaster of Paris. Telegraph insulators are made in two standard sizes (dimensioned diagrams given), the edges of the lips and the groove in the head being unglazed.

M. O'G.

REFERENCES.

803. *Wireless Telegraph Patents.* **A. Turpain.** (Écl. Électr. 29. pp. 77–93, Oct. 19, 1901.)—This is a paper containing descriptions of a number of recent wireless telegraph patents by various inventors.

G. W. DE T.

804. *Telephony without Wires.* **E. Ducretet.** (Comptes Rendus, 134, pp. 92–93, Jan. 13, 1902.)—An account is given of some successful telephonic experiments made with the earth as the only conductor.

J. J. S.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

MAY 1902.

GENERAL PHYSICS.

805. *100-Ton Testing Machine.* **J. H. Wicksteed.** (Inst. Mech. Engin., Proc. 4. pp. 933–938; Discussion, pp. 939–943, Sept., 1901. Paper read before the Glasgow Engineering Congress (Section III.) 1901.)—A description is given of a 100-ton universal testing machine recently built for the engineering laboratory at Glasgow University. The machine is of the horizontal type, the weighing system consisting of an L lever, and a horizontal lever with travelling poise. The chief points of interest are the readiness with which the machine can be arranged for tension, compression, shearing, bending, or torsion; a holding nut on the hydraulic ram whereby the load may be maintained on the specimen for an indefinite time, independent of any leak of water; roller stays to guide the weigh-bridge when compressing the blocks during shearing; the use of an auxiliary poise starting from the fulcrum for loads up to 32 tons, during which the larger poise ($\frac{1}{2}$ ton) is clamped at the short end of the lever; the wheels of the travelling poises are arranged to form a geometrical slide. Full diagrams are given. H. R. C.

806. *A Pendulum Problem of Euler.* **A. Denizot.** (Deutsch. Phys. Gesell., Verh. 3. 15. pp. 213–220, 1901.)—This paper deals with a problem of Euler's, which is an extension of the ordinary compound pendulum to the case in which the pendulum is rigidly attached to a right circular cylinder supported at its ends on two smooth horizontal planes at the same height, so that this cylinder can move freely on the planes without friction. Euler obtained an approximate solution for the case of small oscillations. The author obtains a solution for finite oscillations in elliptic integrals, giving the time in terms of the configuration of the system. He points out that his solution shows the influence of the cylindrical form of the knife-edge of a pendulum on its period—a problem which Bessel, and recently Helmert, have treated by the use of series. W. S.

807. *Experiments with Vortex Rings.* **A. Indra.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 335–357, April, 1901.)—The author describes a large number of experiments with the well-known smoke ring, the box used having two transparent sides. When a "direct" ring issues from the aper-

ture, a "conjugate" ring enters the box, its rotation being in the opposite direction. Experiments with "direct" rings are described, and show phenomena analogous to reflection, refraction, and absorption. The author gives also a full description of the phenomena observed when several apertures are employed, both when they are and are not in the same plane. He then considers the possibility that vortex rings play a part in the dispersion of storm-clouds by cannon firing, but attributes the effect to sound waves, since the experiments of himself and others show that the vortex rings involved cannot reach a sufficient altitude. W. S.

808. *Range of a Projectile (in Vacuo) on an Inclined Plane.* **A. v. Obermayer.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 365–370, April, 1901.)—This is a mathematical paper, in which the author begins by considering the range on a plane inclined at an angle β to the horizontal. The direction of projection is supposed to make an angle α with the inclined plane (or $\beta + \alpha$ with the horizontal), and the velocity of projection is denoted by V. Then if α and V are constant while β varies, the author shows that the locus of the extremity of the range on the inclined plane of angle β, the direction of projection making an angle $\beta + \alpha$ or $\beta + 90° - \alpha$ with the horizontal, is the pair of parabolic paths traversed by projectiles having the same velocity of projection V and initial directions inclined at $90° - \alpha$ or α to the horizontal. The two last parabolas give, of course, the same range on the horizontal plane through the point of projection. Denoting this latter range by R_0 and the range on the inclined plane by R, the author considers for what values of β, R is greater than, equal to, and less than R_0, and gives a tabular statement of the results for a large number of assigned values of α. He then considers certain actual cases in gunnery, and shows that his results explain the rule used in army practice, that to strike a mark considerably above or considerably below the position of the gun, its tilt relative to its platform or "elevation angle" must be smaller than when the range is the same, but the mark on the same level as the gun. Weigner has deduced the same law, taking account of air resistance, and has obtained a general confirmation of his results by experiments with a gun of very short range. W. S.

809. *Determining Small Time Intervals with the Watch.* **R. Etzold.** (Zeitschr. Instrumentenk., Beib. 1. pp. 1–3, Jan. 1, 1902.)—Watches are fitted with a small resonance box of wood to render the beats audible at a distance; the observer has then both hands free. H. B.

810. *An Electrical Tide Indicator.* **L. Y. Schermerhorn.** (Eng. Club Phil., Proc. 19. pp. 82–88, Jan., 1902.)—The apparatus consists of two parts. In the first the rise and fall of a float is utilised to intermittently complete electric circuits, and the currents so produced communicate motion, through the intervention of electric magnets in the second portion of the apparatus, to an indicator arm, through which information concerning the height of the tide is conveyed to the public. The instruments in question are at present working in Philadelphia under the supervision of the United States Coast and Geodetic Survey. Details are fully described in the article in question.
W. H. S.

811. *Propagation of a Small Movement in a Viscous Fluid.* **L. Natanson.** (Acad. Sci. Cracovie, Bull. 1. pp. 19–35, Jan., 1902.)—The author here uses the results and notation of his former memoir [see Abstract No. 14 (1902)].

Assuming that no external forces act, and neglecting higher orders of the small quantities $\frac{\partial u}{\partial x}$ &c., he obtains (1) the equations of dilatation, and (2) the equations of rotation, so called by Duhem. Clebsch, and other writers after him, had shown how a small disturbance in an isotropic solid can be resolved into two small disturbances, one of dilatation and the other of rotation. The author shows that an analogous proposition exists for the small movements in a viscous fluid, at least in certain cases, and that these cases include that of the viscous fluid discussed by himself. Duhem had shown that the method of Clebsch can be extended to a large class of disturbances, provided that certain conditions are satisfied, which are the conditions of this paper.

The equations of motion are presented in the form—

$$\frac{\partial^2 u_1}{\partial t^2} - (b^2 - c^2)\nabla^2 u_1 + T\frac{\partial}{\partial t}\left(\frac{\partial^2 u_1}{\partial t^2} - b^2\nabla^2 u_1\right) = 0 \quad \text{.....(1)}$$

for dilatation, and—

$$\frac{\partial^2 u_2}{\partial t^2} + T\frac{\partial}{\partial t}\left(\frac{\partial^2 u_2}{\partial t^2} - a^2\nabla^2 u_2\right) = 0 \quad \text{.....(2)}$$

for rotation. The equations of motion here obtained are compared with the classic equations for viscous fluid discovered by Navier, Poisson, Stokes, and others. Integrating the equation (2) above given we have—

$$\frac{\partial^2 u_2}{\partial t^2} + \frac{1}{T}\frac{\partial u_2}{\partial t} - a^2\nabla^2 u_2 = A, \text{ a function of } x, y, z;$$

if $f = u_2 - \text{Pot}\left(\frac{A}{4\pi a^2}\right)$, where Pot stands for $-4\pi\nabla^{-2}$, this equation assumes the form—

$$\frac{\partial^2 f}{\partial t^2} + \frac{1}{T}\frac{\partial f}{\partial t} - a^2\nabla^2 f = 0 \quad \text{.....(4)}$$

a generalised form of the "telegraphist's equation." The constant A introduced by this integration is determined. The author then discusses a particular integral of (4); and finally, the effect of using the actual displacements ξ, η, ζ, instead of their derivations u, v, w, when certain constants of the medium are very great, and the viscous fluid becomes what is called a plastic body. S. H. B.

812. *Rock Temperatures at Edinburgh.* **T. Heath.** (Roy. Soc. Edinburgh Trans. 40. 1. pp. 157–186, 1901.)—The readings from May, 1888, to December, 1899, of the four thermometers sunk in 1879 in the Calton Hill rock, at depths of 25, 50, 125, 250 in. respectively, to replace the set provided in 1837 by the British Association, and unfortunately destroyed in 1876, are here tabulated, as also their monthly, quarterly, and annual means; and their readings from 1879, together with the readings of the old set for the forty years of their existence, are discussed in the manner suggested by Lord Kelvin and worked out by Everett in 1860. A difficulty in the discussion arises from the new set having sunk $12\frac{1}{2}$, $10\frac{1}{4}$, $8\frac{1}{2}$, $1\frac{3}{4}$ in. respectively since their establishment, owing to the settling of the fine sand with which the bore-hole was filled up and upon which they rest. With the English foot, the year and the degree F as units, the old and new thermometers give respectively 0·1116 and 0·1150 as the value of $\sqrt{(\pi c/k)}$, and thus 252·2 and 237·5 for k/c, and 133·2 and 125·7 for k (with Regnault's value 0·5283 for c for the rock in question). The range R

of temperature at depth f ft. is given by $\log R = 1{\cdot}30103 - 0{\cdot}0485f$, so that the range is 1° F. at depth 26·8 ft. and 0·01° at depth 68·1 ft.; and, on the average, 6·6 days are necessary for heat to pass through 1 ft. of the rock.

R. E. B.

813. *Temperature of the Soil.* **D. A. Seeley.** (Monthly Weather Rev. 29. pp. 501–503, Nov., 1901.)—The author has taken various observations on the temperature of the soil and of the surface at different elevations, in a hilly district near Chicago. Thermometers were inserted to depths of 3, 6, and 12 in. into the bare or cultivated soil; the nature of the vegetation, and even the colour of the grass, have a marked influence upon the evaporation, and hence upon the temperature. He would cultivate the soil early in the afternoon to lessen the danger of night frosts. The paper is mainly of agricultural interest.

H. B.

814. *Reduction of Records of Rain Gauges.* **M. S. W. Jefferson.** (Monthly Weather Rev. 29. pp. 499–501, Nov., 1901. Remarks by **A. J. Henry.**)—The author proposes to apply corrections to the readings of rain gauges, and criticises the apparent neglect by the officials of the U.S. Weather Bureau of the influence of topography in constructing rainfall maps. —A. J. Henry, who is in charge of the Records Division, regards the proposal as impracticable, and refutes the criticisms.

H. B.

815. *Westward Movement of the Diurnal Barometric Wave.* **O. L. Fassig.** (Monthly Weather Rev. 29. pp. 495–496, Nov., 1901. Paper read before the Milwaukee Convention of United States Weather Bureau Officials, Aug. 27, 1901.)—With the aid of the hourly barometer records of the United States, the West Indies, and also of South America, the author studies the movement of the diurnal barometric wave over the vast area extending from Long. 0° to 140° W., and Lat. 60° N. to 40° S. The charts for the twenty-four hours concern the month of July. This month was selected because the heat equator lies then furthest north, and to eliminate, as far as possible, the influence of the comparative paucity of the southern stations, and of the unequal distribution of land and sea over the two continents. It results that a wave of increasing pressure moves westward over the two continents in the forenoon; it is followed by a wave of diminishing pressure in the afternoon. During the night the distribution of pressure is more uniform, but there is a corresponding secondary period of high pressure in the first half, and of low pressure in the second half of the night, again with a westward movement.

H. B.

816. *Isobar Charts.* **W. v. Bezold.** (Archives Néerlandaises, 6. pp. 564–574, 1901.)—In order to map out the distribution of atmospheric pressure, we imagine surfaces of equal pressures, differing generally by 5 mm., and we represent the intersections of these surfaces, either with the gravitational planes, in which case we obtain isobars in the strict sense, or with perpendicular planes, which yield isobars in vertical section. The author discusses the advantages and disadvantages of the two methods, with special regard to the gradient acceleration. The first method is convenient and generally applied. But we often disregard the fact that the density of the air enters into the formulæ, and that the gradient acceleration increases with rising temperature and with decreasing air pressure. This omission may cause errors of as much as 30 per cent. In cyclonic disturbances, the air as a rule rushes

in from the warmer front on the equatorial side, and the air will be less dense along the front of an isobar than at the rear ; hence the gradient acceleration will be greater than the gradient would indicate. These disadvantages do not affect the second method, which is, however, too difficult for practical application, and resorted to only in mere diagrams. H. B.

817. *Effect of Magnitude on Time Observations.* **H. G. van de Sande Bakhuyzen.** (Archives Néerlandaises, 6. pp. 727–746, 1901.)—Tables are given of the results obtained by means of a special apparatus constructed to show the variation of the time of perception of moving stars of different degrees of brightness over fine wires. The variation is very strongly marked as the stars approach the limit of visibility. The time of perception increases as the brightness diminishes, and the rate of variation is different for different observers. The probable bearing on the variation of personal equation in transit observations is considered. C. P. B.

818. *Total Solar Eclipse of May* 18, 1901 (*Sumatra*). **H. F. Newall.** (Roy. Soc., Proc. 69. pp. 209–234, Jan. 17, 1902.)—The paper is a preliminary report of the observations made by the party financed by the Eclipse Committee. The programme included photographs of the corona for structure and polarisation, of the spectrum of the chromosphere and corona with prism and grating spectroscopes, and visual observations of the corona for distribution of coronium and polarisation. Much difficulty was introduced into the operations by the presence of clouds, but several valuable records were obtained. The negatives of the corona had scales of standard intensities impressed on them, for the measurement of the coronal intensity at varying distances. Evidences of considerable disturbance are visible in the region near the eastern limb, where there is a well-developed prominence.

All the photographs obtained with the Savart plates show marked polarisation of the corona.

Successful photographs of the chromospheric and coronal spectra were obtained with the objective grating. C. P. B.

819. *Total Solar Eclipse of May* 18, 1901 (*Sumatra*). **F. W. Dyson.** (Roy. Soc., Proc. 69. pp. 235–247, Jan. 17, 1902.)—This expedition from the Royal Observatory was furnished with the same instruments which were employed in Spain, 1900, consisting of a 16-in. cœlostat, 12-in. heliostat, two-prism flint spectroscope, and four-prism quartz spectrograph ; also a 4-in. lens. The station selected was on a small island off the west coast of Sumatra. The photographs of the corona were of two classes, large scale for structural detail and small scale ones for recording extensions. Six out of the eight large scale photographs of the corona are good, and the disturbance of the corona near the large prominence is well shown. As most of the photographs were taken through cloud, the spectroscopic results were only partly successful. The spectrum of the corona was recorded from λ5876 to λ3350, with many bright lines, but no absorption. C. P. B.

820. *Total Solar Eclipse of May* 18, 1901 (*Mauritius*). **A. S. D. Maunder.** (Roy. Soc., Proc. 69. pp. 261–266, Jan. 17, 1902.)—The authoress gives details of instruments and exposures employed during the last total eclipse of the sun in Mauritius. Facilities were given for the erection of the apparatus in the Observatory grounds, and by the co-operation of several volunteer helpers,

photographs were obtained with (1) a twin lens camera containing two Dallmeyer stigmatic objectives, (2) a lens of 4 in. aperture and 34 in. focus, (3) a Cooke photo-visual objective of 4¼ in. aperture and 71 in. focus, (4) a portrait lens of 2 in. aperture with telephoto attachment giving an equivalent focal length of 8 ft., (5) a pin-hole camera of 30 in. extension.

The photographs with the stigmatic lenses show coronal extensions to five or six lunar radii from the edge of the moon, and the whole of the series of 14 plates exposed with the Cooke lens are good. C. P. B.

821. *Proper Motions of Faculæ in Longitude.* **A. L. Cortie.** (Astrophys. Journ. 14. pp. 317–322, Dec., 1901.)—The author discusses a series of drawings selected from the Stonyhurst records of sunspots and faculæ. For convenience of recognition, a period of minimum sunspot activity is selected, as the various groups of faculæ are then more easily followed from time to time than when the surface is more or less covered with them.

During the year 1889, 121 different groups of faculæ are recorded, 25 of which are associated with spots, and 13 of these have been selected as giving records for periods varying from 120 to 19 days. Their heliographic coordinates have been determined from the original drawings, and the resulting values are given in tabular form. These show distinct evidence of drift in longitude, and reproductions from the drawings which are included in the paper bear out this conclusion. C. P. B.

822. *Declination and Proper Motion of Polaris.* **E. F. van de Sande Bakhuyzen.** (Archives Néerlandaises, 6. pp. 789–824, 1901.)—A discussion of the measures made at Königsberg since 1820 in order to determine the accurate value of the star's position in declination, and to detect if possible any periodical change. Some observations appear to indicate an increase of the declination between 1825–1845, but the evidence is not conclusive; there appears evidence of a minimum near 1875. C. P. B.

823. *Total Light of all the Stars.* **S. Newcomb.** (Astrophys. Journ. 14. pp. 297–312, Dec., 1901.)—An attempt is made to determine practically the total light of the stars by direct comparison of various regions with standard sources. The discs of selected stars were optically enlarged by being viewed through concave lenses, and the resulting patch of light was compared with the brightness of the sky in the neighbourhood. The author concludes that the total light is about equal to that of 600 stars of magnitude 0. Suggestions are given for the construction of a more perfect instrument for future determinations. C. P. B.

824. *Further Researches on the Spectroscopic Double Star Mizar.* **H. C. Vogel.** (Archives Néerlandaises, 6. pp. 661–667, 1901.)—The photographs of the spectrum of the principal star of the well-known double ζ Ursæ Majoris (Mizar) show a varying amount of doubling of the lines, and the author considers that this is evidence of the fact that the star is a binary system, each one of the pair having the same spectrum. This view, previously announced before the Berlin Academy, is further borne out by a series of fifty-five photographs of the spectra taken between March 24th and June 23rd, 1901. The period of rotation of the pair appears to lie between 20·5 and 20·6 days. The relative motions, as calculated from the measurements of the plates, are given, as well as the differences between these and

the values calculated by the Lehmann-Filhe method. The motion of the system relative to the sun is found to be —14·2 kilometres, as a mean of nineteen measurements. E. C. C. B.

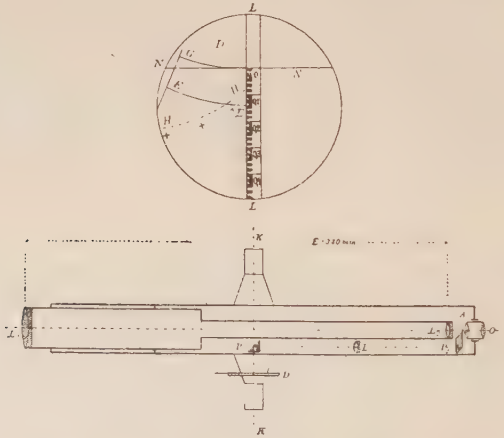
825. *Veramin Meteorite.* **H. A. Ward.** (Amer. Journ. Sci. 12. pp. 453–459, Dec., 1901.)—The author gives a description of this important siderolite, which fell in May, 1880, near Teheran. It now lies in the Palace, and until the present author's visit, there appeared to be no authentic record of its dimensions. Its weight is 113½ lbs. (51⅔ kilogrammes); in shape it resembles an oblong loaf, 16 in. long, 12 in. wide, and varying in thickness from 7 to 8 in. The whole exterior is covered with the hollow markings usually found on metallic meteorites. When broken, the fractured surface appears as a dull, coarse-grained base or cement, in which large crystallised angular grains are imbedded. The inner constituents have been described as "bronzite"; a green, infusible and almost insoluble silicate, probably peckhamite, and granules of nickel iron—all cemented by a fine network of nickel iron. Possibly there are also enstatite and olivine. The specific gravity of a specimen of the meteorite was 4·57. Stony matter constituted about 42·3 per cent., and metallic matter 57·7 per cent. Of the metallic portion the chief constituents were—Fe = 92·06; Ni = 6·96; Co = 0·73; P = 0·10; S = 0·15 per cent. C. P. B.

REFERENCE.

826. *Asymmetrical Oscillations round a Position of Stable Equilibrium.* **F. Richarz** and **P. Schulze.** (Archives Néerlandaises, 6. pp. 695–713, 1901.)—Such oscillations occur when the forces acting on either side of the position of stable equilibrium are not equal to one another at equal displacements: for example, in a magnetic needle whose position of rest does not coincide with the magnetic meridian, in Kohlrausch's sine electrometer, in the ordinary balance for measurement of electrostatic potentials or electromagnetic forces, and other cases. The paper contains a mathematical discussion and experimental confirmations. A. D.

LIGHT.

827. *Hammer and Fennel's Tachymeter - Theodolite.* **E. Hammer.** (Zeitschr. Instrumentenk. 22. pp. 21–26, Jan., 1902.)—The instrument is used for determining horizontal distances and differences in level between itself and a vertical surveying pole, one setting only being made, and without reading an angle of altitude or making a trigonometrical calculation. Results of the first trials were published in the above journal in 1900, and the present paper describes the working of the instrument. In Fig. 1, showing the field of view in the telescope, the lines G, EE and HH belong to a photographed diagram, LL is the image of the surveying pole, and NN the cross wire. Tilting the telescope causes the diagram image to pass across the left half of



the field, the zero line G always touching NN. Taking the numbers from the figure, the "distance" line EE cuts the pole at 0·14, and the "height" line HH cuts it at 0·08. The constants 100 and 20 reduce these numbers to—Horizontal distance = 14 metres; difference of level = 1·6 metres. Fig. 2 gives a section of the instrument. The diagram D is fixed with its plane perpendicular to the axis KK. The two images are formed by $KP_1L_3P_2AO$ and L_1L_2O, the latter by means of the enclosed Porro telescope. The field of view is halved by the edge of the prism A. The limits, with a 4·4 m. pole, are 300 m. and 60 m. respectively. G. E. A.

828. *A New Interference Spectroscope.* **O. Lummer.** (Archives Néerlandaises, 6. pp. 773–788, 1901.)—This is a simple interference apparatus designed for examining the structure of spectrum lines. Two exactly similar wedge-shaped pieces of glass are taken, and are set against one another, the two long sides together. In this way a parallel slab of glass of variable thickness is obtained. Both wedges are coated with a semi-transparent mirror of silver, and one of them is cemented to a glass plate, while the other is movable by a very delicate micrometer screw; the two wedges are held in contact by a thin layer of oil between them, which further serves as a lubricant. When in use, the rays from the collimator are passed through one or more prisms, and then caused to fall on the interference apparatus, an adjustable diaphragm being interposed to regulate the size of the pencil of light. E. C. C. B.

829. *The Bruce Spectrograph of the Yerkes Observatory.* **E. B. Frost.** (Astrophys. Journ. 15. pp. 1–27, Jan., 1902.)—This instrument, designed especially for line-of-sight work, is of the Keeler type, as described by Hale and Ellerman [see Abstract No. 455 (1900)]. In the construction, special care was taken to keep the following in view: (*a*) rigidity; (*b*) permanence of adjustment; (*c*) freedom from mechanical strain; and (*d*) temperature control. The size of the apparatus was defined by the following optical details: The diameter of the beam of light was fixed at 51 mm., the focal length of the collimator at 38 in., and, for greater convenience, the deviation at 180° for the centre ray. The foundation of the mounting consists of a massive circular ribbed iron casting weighing about 200 lbs. From a point 7 in. from the centre of this, there projects a steel tube 5½ in. in diameter, 28 in. long and ¼ in. thick; this carries the prism casting, which is also secured by six oblique steel braces to the main ring casting. The collimator and telescope tubes are respectively 2¾ and 3¾ in. in diameter; both are accurately fitted with flanges to the prism casting, and the collimator tube is also fastened by a flange to the main ring casting, passing through the centre of it and projecting 9 in. beyond it. There are two cameras and lenses, one of 18-in., and the other of 24-in. focus. These can be easily interchanged by the use of bayonet catches on the prism table, and they are further supported by a bracket from the 5½-in. tube which forms the main support of the prism casting. The whole of this part of the apparatus is made of iron or steel to minimise the strains owing to unequal expansion. Each camera takes plates 2 × 4 in. The slit is of simple construction, with one fixed (but adjustable) jaw. Both jaws are polished, so as to reflect back the light they receive on the surface, according to Huggins' arrangement, but both jaws are independently and symmetrically inclined to the axis of the collimator, and their speculum surfaces make an angle of 185° 47′. The apparatus for comparison work is carried on an additional pillar fixed to the ring casting, and is provided with mirrors, or lenses and prism, for throwing the rays of light on to the slit. It is so arranged that when the comparison spectrum has been obtained, the apparatus can be turned to one side, to allow the beam of light from the great objective to fall on to the slit. For the purpose of guiding the large telescope during stellar exposures, the cone of light reflected from each slit is received by a separate, totally reflecting prism, and by a series of prisms, mirrors, and lenses, the two cones are united and brought to an observing telescope at the back of the spectrograph. In this way a power of nearly 800 is brought into play, and the observer, by means of slow-speed control motors, is enabled to accurately guide the instrument. The whole apparatus is mounted on the telescope tube by a series of eight bolts on the main ring casting, which are simultaneously locked by a lever, a layer of ebonite being used as packing to prevent conduction of heat. The spectrograph is provided with a double-walled aluminium case for keeping the temperature constant, and an electric heater and a fan for keeping the air in circulation are fixed in the case; the temperature is controlled with reference to delicate thermometers placed in various parts of the apparatus. The prisms were a source of trouble at first; three made of Mantois flint, No. 3814, had to be rejected through want of homogeneity. These were replaced by three of Jena dense silicate flint (0·998), with faces 57 × 114, 123 and 133 mm. respectively; angles about 63° 35′, with central ray at minimum $\lambda = 4480$. The mean path of rays in the glass equals 195 mm. Owing to the fact that prisms were moulded, and not cut from cast discs, they are not perfectly satisfactory. In dispersive and resolving power this spectrograph is very similar to the Mills instrument at

the Lick Observatory, and to Vogel's Potsdam III. In measuring plates, the wave-lengths of all the lines are calculated by the formula $\lambda = \lambda_0 + \frac{c}{s - s_0}$, three known lines in the comparison spectrum being taken as standards. The wave-lengths, as found, of the comparison spectrum lines are then corrected, and a curve of errors is drawn; corrections are applied from this to the star lines, and, from the new values, the velocity in the line of sight is obtained. A table of measurements of α Arietis is given, showing the small variations obtained on each side of a mean velocity of — 13·66 kilometres per second. E. C. C. B.

830. *Diffraction Theory of the Microscope.* **J. W. Gordon.** (Roy. Micr. Soc., Journ. pp. 353–396, 1901.)—The Abbe diffraction theory, as stated by Abbe's disciples, is discussed at length in order to show that observation does not uphold the theory, and that further improvement of the resolving power of the microscope is not impossible, but may be looked for, *e.g.*, in the use of systems which expand the wave-front of the light from the object, this being partly done by the use of wide-angled objectives. G. E. A.

831. *Theory of Microscopical Vision.* **J. W. Gordon.** (British Optical Journ. I. pp. 67–69, Nov., 1901.)—This is a reply to criticisms on the author's paper [see preceding Abstract], emphasising the necessity of attending to the diffraction within the instrument, and the prevention of undue contraction of the wave-front at any point. G. E. A.

832. *Axis Error of Crystal Plates.* **O. Schönrock.** (Zeitschr. Instrumentenk. 22. pp. 1–14, Jan., 1902. Communicated by the Physikalisch-Technischen Reichsanstalt.)—The coincidence of optic axis and normal in saccharimeter quartz plates being only approximate, the angle between the two, or axis error, has been measured by Gumlich's method. This, hitherto applicable only to quartz plates over 1 mm. thick, gave an accuracy of about 1′. Brodhun and the author have constructed an apparatus to use with Gumlich's method for quartz plates of ordinary size down to 0·3 mm. thick, the accuracy being to several seconds. The greater part of the paper deals with the development of an expression for the axis error from one for the phase difference of the interfering waves. The method consists in placing the plate between the two Nicols to get the cross and rings. The plate is inclined to the line of vision, and the angle $\phi_1 - \phi_2$ measured, which produces the same displacement of rings as turning the plate in its own plane through 180°. The value of the axis error is then determined from the expression—

$$(\phi_1 - \phi_2)/4 \times \cos\phi(2n_0^2 - \sin^2\phi)/(n_0^2 - \sin^2\phi)3/2$$

where $\phi = (\phi_1 + \phi_2)/2$. If $\phi = 0$, the expression reduces to $(\phi_1 - \phi_2)/2n_0$, n_0 being the refractive index of the crystal. The uumbers given for two quartz plates are : axis errors 3′ 43″ and 15′ 25″, the readings varying within 7 seconds.
G. E. A.

833. *Dispersion of Ultra-violet Rays in Transparent Solids.* **F. J. Micheli.** (Archives Néerlandaises, 6. pp. 634–640, 1901.)—The effect of temperature on the refractive indices of fluorspar, rock salt, quartz, and calcspar is investigated by a photographic method, the prisms used being surrounded by a heating jacket with quartz windows. The displacement dl of a certain line being measured for a temp. change of about 22° to 100°, the corresponding change in refractive index is calculated from $\Delta n = (a + bl)dl$, where a and b are

constants, and l is the distance of the first line from another of known refractive index. From Δn is calculated the value ΔN for a vacuum. It is found that, for the above substances, the change ΔN increases as l decreases, whether for calcspar, in which ΔN is positive, or for the others, in which ΔN is negative in the visible region. In the latter case, ΔN disappears for a certain small wave-length, about 220 $\mu\mu$ for quartz and rock salt. Tables of corresponding values of λ, Δn, and ΔN are given for the four substances. G. E. A.

834. *Pressure of Light.* **P. Lebedew.** (Ann. d. Physik, 6. 3. pp. 433–458, Nov., 1901. See also Electrician, Nov. 29 and Dec. 6, 1901.)—This is an experimental paper confirming previous results [see Abstract No. 1059 (1901)]. The pressure produced by light is directly proportional to the energy, and independent of the wave-length. A. D.

835. *Constants of Refraction.* **A. Bromer.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 929–946, July, 1901. From the Physikalisch-Chemischen Institute der K. K. Universität at Vienna.)—The optical measurements were taken by the total reflectometer of Pulfrich, and several inorganic compounds, hitherto little investigated, were dealt with, *e.g.*, lithium sulphate, magnesium bromide, aluminium bromide, nickel sulphate, osmium tetroxide, gold cyanide, &c. A table of values for 22 such substances is given, containing for each, the density of the solution, the molecular weight of the substance, the index for the C, D, and F lines respectively at stated temperatures, the refraction constant of the solution, and the molecular refraction of the dissolved substance. For the calculation of the refraction constant the formula $(\mu^2 - 1)/(\mu^2 + 2)d$ is employed, where μ is the index and d is the density of the solution. It is found, by a preliminary set of experiments upon water at different temperatures and concentrated solutions of aluminium bromide, that this formula gives much greater constancy than either $(\mu - 1)/d$ or $(\mu^2 - 1)/d$. A set of tables illustrating this for a temperature range of about 20° to 50° is given. Four other formulæ for the same expression are cited, but all, for specific reasons, are rejected in favour of the one quoted above. The index of refraction μ was determined by the reflectometer, and the density of the solution either by the Mohr balance or by the pyknometer. To calculate the molecular refraction constant from the refraction constant of the solution, the validity of the Biot Arago law was assumed, and the following expression used : $\frac{m}{q_1}(q_2 r_2 - q_3 r_3)$, where m is the molecular weight of the dissolved substance; q_1, q_2, q_3 are the weights of the substance (free from water), the solution, and the water respectively; and r_2 r_3 are the refraction constants referred to above for the solution and for water respectively. Thus a value of the constant of molecular refraction is obtained for all the substances investigated. From these are derived the constants of atomic refraction for the elements lithium, magnesium, aluminium, chromium, iron, nickel, cobalt, arsenic, rubidium, palladium, cæsium, barium, osmium, gold, mercury, uranium. The true specific gravity, *i.e.*, the ratio of the atomic weight to the atomic refraction, is given, and a comparison with results of Hauke and of Gladstone is given. [See also A. Hauke in the above Sitzungsberichte, 105. 2a. (1896), and Abstract No. 1471 (1899).] J. W. P.

836. *Density and Index of Refraction of Air.* **H. G. Gale.** (Phys. Rev. 14. pp. 1–16, Jan., 1902).—The relation $(n - 1)/d = \text{const.}$, given by Gladstone and Dale, when n = refractive index, and d = density, is, for gases,

practically the same as that of Jamin, viz., $(n^2-1)/2 = \text{const.}$, or Lorentz's: $(n^2-1)/(n^2+2)d = \text{const.}$, since n is, for gases, very nearly unity. A concise summary is given of the experimental tests of the accuracy of these expressions for solids, liquids, and gases, together with a very full bibliography. Substitution of the constant A, of Cauchy's equation $n = A + \frac{B}{\lambda^2}$, for n seems to give good general agreement with any of the forms, while Lorentz's form holds well for many substances through the liquid into the gaseous state. The work done on air not being entirely conclusive, experiments are made using an interference method, the air pressure being measured by applying the inverse principle of the McLeod gauge. Two beams of light pass in parallel through pressure tubes, one of which contains the air tested, and the number of fringes which pass on reducing the air gradually to atmospheric pressure is counted. The additional number to zero pressure is calculated and added, and the results go to show that, if there is any departure from the Gladstone and Dale law up to 20 atmospheres for air, it does not amount to more than 0·1 per cent. G. E. A.

837. *Michelson's Interferometer Curves.* **J. C. Shedd.** (Phys. Zeitschr. 3. pp. 47–51, Nov. 1, 1901.)—The author obtains an equation of the second degree for the interference curves given by Michelson's interferometer, and discusses the various conditions under which the corresponding conic section is a hyperbola, parabola, ellipse, circle, or a pair of right lines. The theoretical grounds are given of the method previously described [see Abstract No. 1056 (1901)] of obtaining the chromatic fringes (zero position). The effect of turning the compensator is also discussed, and the resulting motion of the fringes is shown to afford a simple test for its parallelism with the corresponding plate of the interferometer. W. E. T.

838. *Electron Theory of Light.* **W. Voigt.** (Ann. d. Physik, 6. 3. pp. 459–505, Nov., 1901.)—Hertz modified the general electromagnetic equations by an extended definition of electric polarisation. The theory of the propagation of light in ponderable bodies thus obtained has recently received a fresh impetus from the electron-hypothesis. The author applies the new method to a theoretical investigation of the changes in the optical properties of ponderable bodies produced by mechanical and thermal deformations. Absorption is here considered, and the theoretical conclusions compared with the experimental results of Pulfrich and others. Further papers on dispersion and absorption of mixed or compound bodies are indicated. D. E. J.

839. *Rapid Group-Flashing Lights.* **A. Brebner.** (Proceedings of Section 2 of the International Engineering Congress, Glasgow, pp. 190–193, 1902.)—In order to overcome the difficulties connected with the single beam or double beam apparatus combined with an eclipser, which cuts off all the light simultaneously, the author proposes to use a complete subdivided eclipser of two or more parts, each movable independently of the others, along with an optical apparatus of two or more sides. This system requires a screen of two parts for a bilateral apparatus, and so on. With the aid of the complete subdivided eclipser the power of the lightning-light group-flash can be much increased. W. H. S.

840. *Lamp for Light Treatment.* **S. Bang.** (Elect. Rev. 50. p. 117, Jan. 17, 1902.)—Ordinary arc lamps are not expressly constructed for richness

in ultra-violet rays. The author uses electrodes, such as iron, suitably cooled down. It is almost exclusively the arc between the electrodes that emits radiation. The bactericidal power of this lamp is sixty times that of the usual arc lamp, and five minutes at 1 metre is enough to produce erythema of the skin which lasts several days. A very small lamp (5 amperes, 40 volts) produces as much effect at 1 to 1½ cm. in three to five minutes over an area of 10 sq. cm. as the usual apparatus (60 amperes, 50 volts) in seventy-five minutes, but uses only 1/56 as much energy. A. D.

841. *Kerr Effect in Insulating Liquids.* **W. Schmidt.** (Ann. d. Physik, 7. 1. pp. 142–175, Dec., 1901. Extract from the Göttingen Thesis.)—The chief results of this investigation as to the electro-optical phenomena in question may be briefly summarised thus: (1) The determination of the electro-optical constants may be determined by the compensation method for good and bad insulators to an accuracy of from 2 to 20 per cent.; (2) the dispersion phenomena accompanying the double refraction is different in different substances; (3) the electro-optical constant is considerably influenced by the temperature; (4) this constant, for mixtures, so far as investigated, cannot be derived from any simple law; (5) the moderate value of the constant for water is noteworthy, in view of its other extreme physical and chemical properties. Still more striking is the very high value of the constant for nitrobenzol, being of the order of sixty times that for carbon disulphide. E. H. B.

842. *Dispersion of Magnetic Rotation of Polarised Light in Water.* **L. H. Siertsema.** (Archives Néerlandaises, 6. pp. 826–833, 1901. Communicated by the Physik. Institute, at Leyden.)—Eleven series of measurements of the dispersion were made between the limits $\lambda = 4050$ and $\lambda = 7010$; three series were carried out with an apparatus containing one prism, and a wire cylinder 30 cm. long, with 1,107 turns; the tube containing the water was 55 cm. long and 45 mm. in diameter. The ends, closed with parallel glass plates, were sufficiently removed from the influence of the magnetic field. The tube was also wrapped in cottonwool to guard against temperature effects. The final eight series were made with a much larger apparatus, with the water tube 231 cm. long, set inside wire cylinders with 3,650 turns. Three prisms were here used, giving a total dispersion of 14°. The current used was about 60 amperes, and was measured with a galvanometer. The author discusses the accuracy of the experiments, and eliminates certain sources of error, by readings taken with different positions of the Nicols. The position of the telescope could be read to 0°·01. All the results were plotted on a curve, and required very little smoothing. The smoothed results are given, and the differences between these and the actual observed values are given in eleven columns, one column for each series of experiments. These differences, though sometimes over 1 per cent., are usually less than 0·5 per cent. Both sunlight and the arc were used as sources of light. E. C. C. B.

843. *The Klinkerfues Experiment.* **H. Haga.** (Archives Néerlandaises, 6. pp. 765–772, 1901.)—In repeating this experiment a plane grating spectrometer was employed, and was so set up that the collimator pointed due south. An electric arc was placed due south of the slit, and the rays on their way to the slit were first reflected east by a right-angled prism 1, and then reflected back again, west, by another prism, 2, and finally reflected into the slit by a prism 3. Between the prisms 1 and 2, and 2 and 3, an absorption cell

containing bromine vapour could be placed. If these two positions be called I and II respectively, it follows that, were Klinkenfues' idea true, that the earth carries the ether with it round the sun, the effect produced by placing the cell at I at midday and II at midnight would be different from that produced by having the cell at I at midnight and at II at midday. The experiment was tried by examining the relative positions of the sodium lines from the arc, and three bromine absorption lines between them. No difference whatever could be detected, and therefore the author concludes that, if there be any effect, it must be less than one-thousandth of the distance between the two D lines. Klinkerfues claimed to have obtained an effect of 0·0455 tenth metre. E. C. C. B.

844. *Spectrum of Lightning.* **E. C. Pickering.** (Astrophys. Journ. 14. pp. 367–369, Dec., 1901.)—The article describes the interesting photograph of the spectrum of a lightning-flash, which was fortunately obtained with the Draper telescope of 8 in. aperture, provided with a large objective prism, in July, 1901. As there is no definite comparison spectrum, the recognition of the lines is only approximate, and a table of probable wave-lengths is included. An excellent reproduction of the photograph accompanies the article. C. P. B.

845. *Diffraction of Röntgen Rays.* **P. Walter.** (Phys. Zeitschr. 3. pp. 137–140; Discussion, pp. 140–143, Jan. 1, 1902. Paper read before the 73 Naturforscherversammlung at Hamburg.)—This is an account of the results obtained by the author during a repetition of Haga and Wind's experiments [see Abstract No. 1871 (1899)] on the subject. Greater care was taken to secure the apparatus from vibration, and by the use of a special form of tube, homogeneity of the rays was aimed at. By using a greater amount of energy, the exposure of the plate was reduced from 200 hours to about 5 hours. As a final result, no diffraction was observed. In the discussion which followed, **C. H. Wind** criticised some of the author's conclusions as to the homogeneity of the rays used, pointing out that equal hardness in two cases does not necessarily imply that the two streams are homogeneous, either on the hypothesis that the rays are waves of short length, or on the ionic theory. R. S. W.

846. *Absorption of Röntgen Rays by Aqueous Solutions.* **R. K. McClung** and **D. McIntosh.** (Phil. Mag. 3. pp. 68–79, Jan., 1902.)—The absorbing power of different solutions was compared by the following method: Two metal plates kept at different potentials were arranged parallel to each other, and the X-rays allowed to pass between them. Thus a current is set up between the plates, which will be proportional to the intensity of the rays, provided other conditions remain the same. If the current which passes between the plates is measured for different intensities of rays, a direct comparison of the intensities is obtained. The potential gradient which was employed between the plates was about 70 volts per cm., and the current passing was measured by means of a quadrant electrometer. In this way the relative amounts of rays which pass through different solutions were ascertained. The permeability of any given substance was found to be the same for rays of different intensities. An increase in the amount of salt in solution produced an increase in the absorption of the rays. These, however, are not directly proportional, but from the form of the curves showing the variation of absorption with density of solution, the relation appears to be a logarithmic

one. These results agree with those previously obtained by Blythswood and Marchant [see Abstract No. 827 (1900)]. The list of chlorides of various metals investigated, arranged in order of increasing absorbing power, the solutions all having the same density 1·06, is as follows: Sodium, magnesium, calcium, potassium, ammonium, hydrogen, manganese, copper, zinc, barium, strontium, cadmium, mercury, lead. The absorption in the case of different salts depends on two factors, the kation and the anion. As a rule, increase of atomic weight is accompanied by increase of absorption. The results obtained agree in general with those arrived at by previous investigators.

J. J. S.

847. *Colouration Produced by Röntgen Rays.* **G. Holzknecht.** (Deutsch. Phys. Gesell., Verh. 4. 2. pp. 25–28, Jan. 24, 1902.)—Goldstein has described the colouration produced in various salts by the action of kathode rays [see Abstract No. 1311 (1901)]. Similar effects are obtained with ultra-violet light, with the radiation from the electric discharge through gases, and with the radiation from radio-active substances. The author, in the present paper, describes how he has obtained similar changes of colour in different salts of the alkali metals, through the action of Röntgen rays. J. J. S.

848. *Radiographic Equipment for Field or Base Hospitals.* **J. Hall-Edwards.** (Roentgen Ray, Archives, 6. pp. 31–39; Discussion, p. 39, Jan., 1902.)—The author points out that the somewhat sanguine expectations entertained at the beginning of the South African War, as to the benefits to be derived from radiography for the localisation of bullets and shell fragments and the diagnosis of wounds, have not been fully realised, owing mainly to difficulties arising from lack of previous experience. The great value for the saving of life has, however, been conclusively demonstrated, and all such obstacles can and will be removed in the near future. The radiographic apparatus supplied to several hospitals consisted of a 12-in. coil with separate condenser and platinum contact breaker, two "lithanode" accumulators, a Mackenzie-Davidson localising couch, a cross-thread localiser, a fluorescent screen, and all the required accessories, and was quite satisfactory. It was found useless to depend on accumulators sent ready charged from a distance, owing to their handling in transit. Primary batteries for charging the accumulators were found to be useless. A bicycle type foot-motor and dynamo were tried for charging, but no one could be found with strength to work it. The author advises the use of an oil engine, which, for hot climates, should be capable of using heavy oil. This means confining localisation work to the base and general hospitals. A small portable set of radiographic apparatus, nevertheless, might be used in field hospitals with great advantage, not for the definite localisation of bullets, but for a preliminary investigation, enabling the surgeon to discover whether the case is light or serious. The author suggests that, when using the triangulation method in connection with the Mackenzie-Davidson couch and the cross-thread localiser, the two exposures should be made on separate plates instead of on one, which would prevent the first image being obscured by a subsequent exposure, and permit, if desired, an appeal to the Wheatstone stereoscope. The latter should, in his opinion, be included in every base-hospital equipment. Many sets supplied remained unused from the absence of medical officers trained to use them. G. G.

HEAT.

849. *A Viscosity Thermometer.* **A. Job.** (Comptes Rendus, 134. pp. 39–41, Jan. 6, 1902.)—Barus and Callender have suggested [see Abstract No. 814 (1901)] that the viscosity of a gas might be utilised for temperature measurement. Job here describes a method of applying his viscosity apparatus [see Abstract No. 1027 (1901)] in such a way that the variation of viscosity, as temperature changes, shall be made a measure of the change. A 15 per cent. solution of soda is placed in a bottle and corked, there being three holes in the cork—two for the passage of electrodes, and one to allow gas, produced by electrolysis when a current is passed, to escape. This gas is allowed to pass through a porcelain tube of 1 mm. diameter, in which lies a platinum wire 5 cm. long. Thus a very fine annular passage is allowed for the gas. Suppose this porcelain tube is placed in a furnace, the viscosity of the gas decreases and the volume escaping increases. Now the measurement made is not that of the escaping volume, but a much less tedious one, viz., the pressure of the gas on entering the porcelain tube. This is read by a sensitive manometer. To calibrate the manometer, the apparatus is put side by side with any known thermometer. The author has obtained excellent results. *The relation between temperature and pressure is a simple linear one.*

P. E. S.

850. *Tempering of Iron Hardened by Overstrain.* **J. Muir.** (Roy. Soc., Phil. Trans. 198. pp. 1–31, Jan. 23, 1902.)—Steel hardened by overstrain (such as permanent stretching) may have its original properties restored by the usual process of annealing. The author now shows that this may be accomplished, not only at a fairly high temperature, but at any temperature above 300° C. This tempering may be also applied to wrought iron. The experiments were carried out on rods of iron or steel about $\frac{3}{8}$ths of an inch in diameter and 11 in. long, the elastic condition of the material being in all cases determined by means of tension tests made with a 50-ton testing machine at the Cambridge Engineering Laboratory, and an Ewing extensometer. The annealing was carried out in a Fletcher gas furnace, 2 ft. long, the specimens being protected from direct contact with the flame by enclosing them in a thick porcelain tube. Temperatures were measured by means of a Callendar's direct-reading platinum-resistance pyrometer. In the case of some samples of steel, a microscopic examination was made, and the processes used for the preparation of the samples are described. A plate showing the structure under the microscope when the samples were etched with nitric acid, and also when stained with cocoa, is of interest. [See also Abstract No. 751 (1901).]

W. W. H. G.

851. *Heat Absorption by Carbonic Acid.* **J. Koch.** (Öfvers. Kongl. Vet.-Aked. Stockholm, Förh. 58. No. 6. pp. 475–489, 1901.)—These researches were made with a view to confirm Ångström's theory. The absorption of radiation from sources at low temperature by carbonic acid strata of varying thickness was tested by Ångström's method, the result being that absorption at first increases rapidly with the thickness of the stratum, while for any considerable thickness, in accordance with Ångström's views, it will not vary greatly

with further increase. The disagreement with Arrhenius's results is pointed out, and the partial disagreement with Tyndall's data is accounted for. Measurements are given showing the influence of the terminal rock-salt plates. A. G.

852. *Heat Absorption by Atmospheric Carbonic Acid.* **K. Ångström.** (Öfvers Kongl. Vet.-Aked. Stockholm, Förh. 58. No. 6. pp. 381–391, 1901.)—The author maintains his former conclusions [see Abstract No. 807 (1901)] against the criticisms of Arrhenius [see Abstract No. 1907 (1901)], who gives 63 per cent. to 91 per cent. for the maximum, and maintains that it varies greatly with the percentage of CO_2. The author adduces the differences in behaviour of the absorption spectra of water vapour and carbonic acid respectively, as determined by Paschen, Ruben, and Aschkinass, together with his own work on the influence of density on the absorption by carbonic acid, showing clearly that, with increase of density, the amount of absorption will increase much more rapidly than proportionality would require, in support of his own conclusions that the main factor in determining the absorption is the amount of water vapour present. Finally, the author discusses the influence of adding another gas on the absorption spectrum of carbonic acid, the behaviour established by Paschen being another instance in favour of his views. A. G.

853. *Convection of Heat by Air-Currents.* **A. Crichton Mitchell.** (Roy. Soc. Edinburgh, Trans. 40. 1. pp. 39–47, 1901.)—Newton's law of cooling was given by him for a body "not in still air, but in a uniform current of air." This condition has since been generally ignored. From experiments on the cooling of a copper sphere, 2 in. in diameter, in uniform currents of air produced by a Blackman fan, the temperature at the centre of the sphere being measured thermoelectrically, the author concludes that, at least within the limits of 200° C., for temperature-excesses, and 1,000 metres per minute for air-speeds, Newton's law is accurate up to a temperature-excess which increases with increasing speed of the air-current. Thus for temperature-excesses 40°, 80°, 120°, 160°, 200°, the rates of cooling (in degrees per minute) are 3·9, 8·0, 12·0, 16·2, 20·6, for a speed of 271 m. per min., but 8·9, 17·8, 26·7, 35·6, 44·5 for a speed of 1,031 m. per min. Now the loss by radiation depends on a power of the temperature-excess greater than 1, but its ratio to the loss by convection greatly diminishes as the air-speed increases, so that, if the loss by convection is proportional to the temperature-excess, the whole loss will follow this law more approximately, the greater the air-speed. Curves are given showing the variation of the rate of cooling, at a given temperature-excess, with the air-speed. The law of dependence seems to be approximately that of simple proportion, up to the speed of 450 m. per min., which is about that when the air-motion becomes turbulent. R. E. B.

854. *Heat of Formation of Chlorine Hydrate.* **de Forcrand.** (Comptes Rendus, 133. pp. 1304–1306, Dec. 30, 1901.)—Two methods are available for measuring this quantity, the first by direct experiment, the second by calculation from the dissociation curves of the hydrate. The heat absorbed by the solution of chlorine hydrate in water was found by Le Chatelier to be 14, and the heat of solution of gaseous chlorine 3 calories. The resulting value for the heat of formation of chlorine hydrate is 17 calories—

$$Cl_2 \text{ gas} + nH_2O \text{ liquid} = Cl_2nH_2OAq \ldots + 17 \text{ cal.}$$

This value, however, is doubtful, as Berthelot found from 2·94 to over

6 calories for the heat of solution of chlorine; the author proves that these irregularities are not due to production of the hydrate. This compound, which is prepared in presence of excess of water, and at temperatures between 2° C. and 5° C., is a paste which contains from eight to twenty times more uncombined water than hydrate of chlorine; this water contains small amounts of dissolved chlorine. Assuming the formula of the hydrate to be $Cl_2 7H_2O$, the total amount of chlorine present as hydrate can be found, and also the true heat of solution. The mean of three experiments gives this as — 15·63 calories; on adding the heat of solution of chlorine gas + 2·94, the value of the formation heat of the hydrate is found to be 18·57 calories. By calculations from the dissociation curves of chlorine hydrate, as found by Isambert, Roozeboom, and Le Chatelier, the mean value 18·06 calories is obtained; this is subject to a correction for the vapour tension of the water produced, which brings the value to 18·16 calories. The number obtained by direct experiment is 18·57, and the mean 18·36. The equation is—

$$Cl_2 \text{ gas} + nH_2O \text{ liquid} = Cl_2 nH_2O Aq + 18{\cdot}36 \text{ calories.}$$

The author will publish a further paper on the exact composition of the hydrate. W. C. B.

855. *Specific Heats of Electrolytes in Solution.* **W. F. Magie.** (Amer. Phys. Soc., Bull. 2. pp. 23–24, 1901.)—Thomson found the specific heats of many aqueous solutions not to agree with the Joule-Woestyn law. This may be supposed to be due to dissociation, as he only examined electrolytes, and the law of mixtures has been found good for many non-electrolytes. However, the supposition that the solvent retains its specific heat unchanged, and that each of the undissociated and dissociated parts of the solute possesses a constant specific heat, is found to lead to a negative specific heat for the dissociated portion. Therefore it is assumed that a portion of the solvent, proportional to the degree of dissociation, reacts with the dissociate solute, so that its freedom, and therefore its specific heat, is diminished. The resulting formula for the heat capacity, $\phi = Ms + m\sigma - nk$, in which M and m are the masses, s and σ the specific heats, of the solvent and solute respectively, n is the degree of dissociation, and k a constant, is verified for all the solutions tried with the single exception of potassium nitrate. [See also Abstract No. 2125 (1901).] W. E. T.

856. *Compressibility and Cohesion of Fluids.* **O. Tumlirz.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 437–448, May and June, 1901.)—By integrating, while T is considered constant, the equation (1) of Abstract No. 622 (1901), and No. 101 (1902), the author deduces $(p + P)(v - a) = T/12{\cdot}225m$ as the equation of state of the fluid, P being a function of the temperature. Considerations are put forward to show that P is the cohesion-pressure of the fluid, and it is suggested that it may be independent of the specific volume, only at temperatures considerably below the critical temperature, *e.g.*, if of the form $\theta(T)\{1 - e^{-\chi(T)v^2}\}$, it may reduce to $\theta(T)$ for the fluid state, and to $\theta(T)\chi(T)/v^2$ for the vapour state. Stefan, treating the latent heat of evaporation of a liquid as due to the work done (A) in bringing the particles from the interior of the liquid into the surface, and the work done (B) in bringing them from the surface into the vapour space, has pointed out certain assumptions under which A and B are equal. The calculation of P from the above equation allows of this being tested, for $A = Pv$, and $A + B$ can be found

from the value of the latent heat of evaporation. Tables are given showing the results for carbon bisulphide, chloroform, benzine, water and ethyl alcohol. For the first three, at lower temperatures A and B are approximately equal, while for the other two, and for carbon bisulphide at higher temperatures, they are very different ; thus, at 0° C. for water, B is 3·694 times as great as A. W. E. T.

857. *Influence of Gravity on the Distribution of Temperature in a Gas.* **F. de Boer.** (Archives Néerlandaises, 6. pp. 641–649, 1901.)—Considering an atmosphere of one kind of molecule, in equilibrium above an immovable earth, and supposing its surface plane, gravity not to vary with height, and no interchange of heat by conduction or radiation to occur, and that, if any shock occurs between two molecules which modifies the velocity of a particle, there corresponds at the same moment another shock, by which another particle acquires a velocity corresponding to the former velocity of the other particle, the author shows that t/δ^2 is constant for the various layers, and that $3p = \delta(v^2 - 2gh)$, if the initial velocity (v) of a particle rebounding from the earth is the same for all, and if, among the initial velocities, all directions in space are equally represented. If the initial velocities are not supposed equal, Maxwell's law of distribution is shown to lead to the temperature being independent of the height, and to be the only one which is the same throughout if the temperature is the same throughout. A possible law of distribution is also given without the assumption of constant temperature being made, and the laws are extended to gaseous mixtures. W. E. T.

858. *Temperature of Inversion of the Joule-Thomson Effect for Hydrogen.* **K. Olszewski.** (Akad. Sci. Cracovie, Bull. 9. pp. 453–459, Dec., 1901.)—At — 78° C. hydrogen is slightly warmed, and at — 83° C. it is slightly cooled, on expansion from 117 atmospheres to 1 atmosphere without doing work, the temperature of inversion seeming to be — 80·5° C., which agrees well with the temperature — 79·3° C. deduced from the formula by which Rose-Innes represents the results of Thomson and Joule : hence, for the liquefaction of hydrogen by the Hampson or Linde method, we need not employ a stronger cooling agent than solid carbonic acid mixed with ether. For the temperature of inversion for air, the Rose-Innes formula gives 360° C. ; and if we take — 140° C. for the critical point of air, the theory of corresponding temperatures gives — 232·6° C. for the critical point of hydrogen, that experimentally found by the author being — 234·5° C. R. E. B.

859. *Velocity of Flow of Crystallised Substances.* **G. Tammann.** (Ann. d. Physik, 7. 1. pp. 198–224, Dec., 1901.)—According to the hypotheses of Poynting and Ostwald, the relation between temperature and pressure for a two-phase one component solid-liquid system varies according as the melt can or cannot flow freely away. Thus, according to these views, ice will melt, provided the water can escape, at much lower pressures than those corresponding to its ordinary pressure-temperature equilibrium curve. The author tests these views by measurements of the plasticity of ice, phosphorus, naphthalene, and piperine. The substance was contained in a steel cylinder of narrow bore closed at one end by a screw, and was pressed down by a small plunger. Pressure was communicated to the plunger by a rod actuated by a lever, and as the plunger sank into the substance, the latter was squeezed upwards, between the sides of the plunger and the cylinder, into an open

space above. Varying weights were hung at the end of the lever-arm, and the rate of sinking of the plunger was measured by following the motion of a point on the lever-arm. This was done by screwing down a metal piece which closed the circuit of an electric bell when it touched the lever. When melting occurs, the plunger suddenly sinks as far as possible. The hypotheses of Poynting and Ostwald were disproved. It was found that the melting-points so obtained for ice corresponded to the pressures in the manner indicated by the ordinary pressure temperature curve for ice-water. In the case of ice and white phosphorus, the plasticity increases very rapidly with the deforming force and with the temperature, while in the case of naphthalin and piperin (both crystallised and amorphous), there exists, for certain temperatures, a *maximum* of plasticity with increasing pressure. The author criticises the theoretical considerations advanced by Poynting and Ostwald, and concludes that there is no valid theoretical argument in favour of the existence of the second melting-point curve. F. G. D.

860. *The Equation of State of Gases and Liquids as a Power Series.* **H. Kamerlingh Onnes.** (Archives Néerlandaises, 6. pp. 874–888, 1901. Communicated by the Physik. Institut at Leyden.)—The series development—

$$pv = A + \frac{B}{v} + \frac{C}{v^2} + \frac{D}{v^4} + \frac{E}{v^6} + \frac{F}{v^8}$$

is applied to combine the measurements of Ramsay and Young and of Amagat on ethyl ether. The coefficients A, B, &c., are termed *virial coefficients*, and are functions of the temperature. The above expression can be transformed into—

$$\lambda p'v' = A' + \frac{B'}{\lambda v'} + \frac{C'}{\lambda^2 v'^2} + \frac{D'}{\lambda^4 v'^4} + \frac{E'}{\lambda^6 v'^6} + \frac{F'}{\lambda^8 v'^8},$$

where p' and v' now denote *reduced* pressure and volume, and λ is a coefficient determined by the critical data. The coefficients A', B', &c., are termed the reduced *virial coefficients*. Virial coefficients calculated from Ramsay and Young's measurements on ether at 0° C. (liquid-vapour equilibrium), combined with Maxwell's criterium, are found to reproduce Amagat's measurements of the compressibility of liquid ether at pressures varying from 200 to 3,100 atmospheres, with very considerable accuracy. It is also found that the reduced virial coefficients can be expressed as temperature polynomials of the form—

$$B' = b_1 t + b_2 + b_3 \frac{1}{t} + b_4 \frac{1}{t^3}$$

$$C' = c_1 t + c_2 + c_3 \frac{1}{t} + c_4 \frac{1}{t^3} \text{ &c.}$$

Thus the complete behaviour of a substance, both as gas and liquid, can be expressed with very considerable accuracy by means of 25 constants. The temperature-coefficients of the reduced virial coefficients for different substances possess a specific character. In order to bring different substances into line, these temperature-coefficients are altered so that the behaviour of each particular substance is represented within the limits of experimental accuracy, and so that the special reduced virial coefficients for various substances agree at a temperature lying far beyond the region of observation. Tables showing this are given. F. G. D.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

861. *Theory of Electrions.* **Kelvin.** (Archives Néerlandaises, 6. pp. 834–861, 1901; and Phil. Mag. 3. pp. 257–283, March, 1902.)—The author propounds a modification of the one-fluid theory of Electricity of Æpinus according to which this fluid is made to consist of minute equal and similar atoms, which he calls *electrions*, smaller than the atoms of ponderable matter, and capable of permeating freely both the atoms and the spaces between them. The atoms are assumed to be spherical, and, as in the theory of Æpinus, repulsion is assumed between atoms and also between electrions, with attraction between atoms and electrions outside of them; and both repulsions and attractions are assumed to follow the law of inverse squares, in accordance with the researches of Cavendish and Coulomb. As a tentative hypothesis, it is assumed that the attraction experienced by an electrion entering an atom undergoes no abrupt change, and decreases to zero simply as the distance from the centre when the electrion, approaching the centre, is within the spherical boundary of the atom, as would be the case if the electric virtue of the atom were due to uniform distribution through the atom of an ideal electric substance of which each infinitely small part repels infinitely small portions of the ideal substance in other atoms, and attracts electrions according to the law of inverse squares. Corresponding suppositions cannot, however, be made for the force between two overlapping atoms; for freedom must be reserved for the addition of an attraction or repulsion, according to any law of force that may be found convenient for the explanation of electric, elastic, and chemical properties of matter. The neutralising quantum of electrions for any atom or group of atoms has the same quantity of electricity of one kind as the atom or group has of the opposite kind.

For a single atom this quantum may or may not consist of an integral number of electrions, *e.g.*, the molecule of a diatomic gas might conceivably have an odd number of electrions for its quantum, in which case the single atoms of the gas, if capable of separate existence, would necessarily be electrified. The author infers from experimental results, such as Varley's discovery [Proc. Roy. Soc. 19. pp. 239–40, 1871] of the molecular torrent of resinously electrified particles from the kathode in highly exhausted tubes, that the electrions must be considered as resinously electrified, and a void atom, therefore, as a little globe possessing as an essential quality vitreous electricity uniformly distributed through it or through a smaller concentric globe; and that ordinary ponderable matter, not electrified, consists of a vast assemblage of atoms, not void, but having, within the portions of space which they occupy, just enough electrions to annul electric force for all places of which the distance from the nearest atom is large in comparison with the diameter of an atom or molecular cluster of atoms. The author first considers the conditions of equilibrium of the electrions in the case of one atom approaching another until they overlap, and ultimately become concentric. If the two atoms are polyelectrionic, the remarkable result is arrived at that, after separation, the number of electrions in the smaller atom will be increased, and that in

the larger decreased, which would explain the origin of electrification produced by pressing together and then separating two solids. The author suggests that this may probably be the explanation of the fact that ground glass is resinous relatively to polished glass, as the process of polishing might be expected to smooth down the smaller atoms, and to leave the larger atoms more effective in the surface ; and also of E. Murray's discovery that burnishing metallic surfaces, previously cleaned with emery-paper, makes them more positive in the Volta Scale [see Abstracts Nos. 1065 and 1341 (1898)]. The author discusses various possible stable configurations of electrions within an atom, and many interesting problems are indicated, after which he shows that these hypothetical atoms realise perfectly, for sparse assemblages, Faraday's suggestion [Experimental Researches, § 1679] of "small globular conductors, as shot," to explain the electro-polarisation which he discovered in solid and liquid insulators. It is suggested that the hypotheses here put forward seem to open the way to a very definite detailed dynamics of electrolysis, of chemical affinity, and of heat of chemical combination. If, however, we were tempted to assume further that all chemical action is electric, and that all varieties of chemical substance are to be explained by the numbers of electrions required to neutralise an atom or set of atoms, then, since all the electrions are assumed to be alike, it would be necessary to postulate different laws of force between the different atoms. On the electrionic hypothesis, a solid would, at the absolute zero of temperature, necessarily be a perfect insulator of electricity under the influence of electric forces sufficiently moderate not to pluck electrions out of the atoms in which they rest stably when there is no disturbing force, but, as the temperature rises, electrions will be shot out of their atoms, and, if in an electric field, there will be a resultant travel in the direction of the electric force, thus explaining the increase of conductivity of bad conductors with rise of temperature. To explain the conductivity of metals on the same principles, it is only necessary to assume that metallic atoms are so crowded with electrions that the latter are always being spilt out of each atom by intermolecular and electrionic thermal motions, not only at ordinary atmospheric temperatures, but even at temperatures as low as 16° above the absolute zero, as it was in the neighbourhood of this temperature that Dewar found [Bakerian Lecture on Nadir of Temperature, June, 1901] that various metals have still very high conductivity, and it is quite easy to conceive that, with rising temperature, the electric conductivity may reach a maximum and then decrease ; for, while some thermal motion is necessary for conductivity, too much of such motion must impede the freedom with which an electron can thread its way through the crowd of atoms to perform its function of electric conduction. The paper concludes with illustrations of the applicability of the author's hypotheses to the explanation of the phenomena of the pyro-electricity and piezo-electricity of crystals, including examples of the possibility of producing the octo-polar electric æolotropy of Haüy in a homogeneous assemblage of tetra-electrionic atoms. G. W. DE T.

862. *The Theory of Electrons and Electric Resistance in a Magnetic Field.* **E. van Everdingen, Jr.** (Archives Néerlandaises, 6. pp. 294–302, 1901.)—This paper deals with the electron theory of conduction in metals. J. J. Thomson has worked out [Paris Congress Report, 1900] an increase of resistance in bismuth in a magnetic field. The author has revised the calculation, arriving at the unexpected result that the irregular movements of the electrons would cause, on the whole, a diminution of resistance, and

prevent the magnetic force from producing the Hall effect. This is modified by the electric fields between the electrons and the comparatively stationary charged ponderable particles, which would probably bring about the observed results. Further research is being carried on. A. D.

863. *Automatic Registration of Atmospheric Discharges.* **J. Fényi.** (Comptes Rendus, 134. pp. 227–228, Jan. 27, 1902.)—A coherer, consisting simply of two crossed pieces of metal, is placed in series with a coil, at the centre of which is suspended a mirror carrying a magnetic needle. A clock-work or bell encloses the coherer, and by its vibrations, when a current passes, causes decoherence. A fraction of a volt is found to give the best results. When a lightning-flash occurs, coherence takes place, and the mirror is deflected. Very good automatic records have thus been obtained during the past year. R. S. W.

864. *Ascending and Descending Air-Currents and Atmospheric Electricity.* **F. Linke.** (Ann. d. Physik, 7. 1. pp. 231–235, Dec., 1901.)—In the "normal" condition of the earth's electric field the earth possesses a negative charge, and consequently positive charges must be regarded as present in the atmosphere. The presence of those positive charges has recently been explained on the ionic theory; according to Ebert's measurements [see Abstract No. 1917 (1901)], the positive ions in the atmosphere are more numerous than the negative, the excess of positive and also the total number of ions decreasing upwards. The author considers that this theory is incompetent to explain the high potential differences occurring in connection with the phenomenon of lightning, and shows that a satisfactory explanation of this and other phenomena of atmospheric electricity is given by the motion in the earth's field of clouds and layers of vapour. The principle used is that when a conductor, having a charge Q and capacity C, is in electrostatic equilibrium at a place where the potential is V, then, when it moves to a place where the potential is V', a quantity of electricity $C(V - V')$ becomes "free" and disturbs the field. This principle, along with the effects of induction and coalescence of drops, explains how the high potential differences required for lightning are the effect of rapid air-currents. The author has verified his assumptions by observing the state of the same cloud at different levels during a balloon ascent. W. S.

865. *Atmospheric Electricity at Zakopane.* **A. Witkowski.** (Acad. Sci. Cracovie, Bull. 1. pp. 7–10, Jan., 1902.)—Observations made in August and September, 1901, in the large and shallow valley of Zakopane, north of the Tatra Mountains, at an altitude of 850 m. The collector electrodes contained a few mg. of radio-active barium chloride; the indications of these electrodes were identical with those of flames, and more stable. Exner's potential maxima of 8 a.m. and 8 p.m. were well accentuated; his sudden rise of potential at the moment of sunset was observed a few times (120 volts maximum), not as a rule. Negative and positive charges were dispersed with equal rapidity. On the Swinica, however, at an altitude of 2,000 m., the negative charges disappeared much more rapidly (ratio 15·5 : 4·5). H. B.

DISCHARGE AND OSCILLATIONS.

866. *Electric Discharge in Gases.* **W. B. v. Czudnochowski.** (Phys. Zeitschr. 3. p. 129, Jan. 1, 1902.)—A T-shaped tube contains a kathode at

either end of the cross-piece, one of them being plane and the other concave. A single anode is inserted at the end of the other branch. At comparatively high pressures the luminosity is the same in both ends of the branch containing the kathode ; a reduction of the pressure causes all the discharge to go to the plane kathode. By placing the finger in the neighbourhood of the concave kathode all the discharge is diverted to it, but immediately springs back on the finger being removed. The luminosities near both kathodes are also equal when an equal number of striæ occur in their respective branches. Should the same number not be present, there is a considerable difference in the luminosities. R. S. W.

867. *Electrical Discharge in Wide Vessels.* **O. Lehmann.** (Ann. d. Physik, 7. 1. pp. 1–28, Dec., 1901.)—The author describes and gives the results of a number of experiments undertaken with the object of ascertaining what alterations take place in the character of the electrical discharges through rarefied gases, when, for the narrow tubes commonly used, spacious receptacles are substituted. Those here employed consisted of two large bell-shaped air-pump receivers cemented together. The form of the discharge then shows that the conditions are much simpler than with the customary narrow tubes and small electrodes. The normal form, which is maintained throughout—even if the strength of the current is such as almost to form an arc—is the glow discharge, characterised by the absence of the so-called positive column of light. The kathode is surrounded by three strata, the first a seam of yellow light, while the anode is enveloped by a film of pinkish positive glow-light. At a suitable pressure of air, an e.m.f. of not more than 360 volts suffices to maintain the discharge, and the dark space attains a thickness of 30 cm. and more. Figures obtained experimentally show that, provided the air pressure remains unaltered, the thickness of the dark space of the kathode section decreases when the e.m.f. and currents are increased, and *vice versâ*. Experiments made for the purpose of ascertaining the smallest e.m.f. sufficing to obtain a discharge show that, with low voltages, such as 430, at which a discharge takes place when the air pressure is 0·15 mm., and which remains unaltered even when the current is increased from its minimum value of 3·5 to 7 milliamperes, the stoppage of the current does not, under the circumstances described, raise the potential, as is usually the case, but leaves it unchanged. When a condenser of large capacity is used for supplying the current, and the conducting wires are of low resistance, the discharge at a low voltage appears to be continuous, while, on increasing the voltage, a brilliant display of sparks is witnessed, filling the whole receptacle with a blinding white light. Even at a voltage, however, which hardly suffices to secure the passage of the discharge, and when the latter does not occur spontaneously, though the electrodes are connected with the surfaces of the condenser, it suffices to excite a magnetic field of proper strength, and to place it in a suitable position, to produce brilliant discharges accompanied by a loud crackling noise, quite startling to those who have only witnessed discharges in the ordinary vacuum tubes.

The author in his book on "Discharges," has shown that under certain circumstances, the positive light of the anode can be forced to advance to the limit of the light of the kathode. His more recent researches show that this positive light can even be made to traverse the outer luminous stratum of the kathode until it reaches the dark space, while, when the dark space extends close to the glass wall of the oval receptacle, the anode glow-light can force itself through between the dark space and the glass wall. In the remainder

of the experiments described in this paper, the author deals with glow discharges passing through wire nets, the effect of intervening diaphragms, the stratification of the negative light, the interpenetration of two discharges, and the effect of hollow and of concentric electrodes. The author deems the material so far collected insufficient for the explanation of the phenomena, but suggests that, by further experiments it may be possible to ascertain whether, as is assumed in the older theory, the process of discharge consists essentially in a sudden disappearance of the dielectric condition of polarisation, the electric energy being transformed into radiant heat and other forms ("disruptive discharge"), while positive and negative discharges alternate in quick succession, or whether, as is demanded by the newer electron hypothesis, this process represents a combination of two or more open currents of different kinds, which appear simultaneously, and by combination form a closed current, or finally, whether radiancy is merely an accompanying phenomenon, while the current itself passes continually, and without the production of light, through the gas, as through an electrolyte, so that the observed strata and lines exactly represent the underlying reality. In the latter case, the explanation of the polar differences by an accumulation of electrified air, suggested by the author on a previous occasion, would appear to be untenable. G. G.

868. *Discharge of Electricity from Glowing Platinum, and Velocity of the Ions.* **E. Rutherford.** (Phys. Rev. 13. pp. 321–344, Dec., 1901. Paper read at the Denver Meeting of the American Association for the Advancement of Science, Aug., 190...)—In a former paper [see Abstract No. 2147 (1901)] the author has given a theoretical discussion of the conductivity of gases when the ionisation is confined mainly to the surface of one electrode. The present experimental investigation was made to test the validity of some of the conclusions arrived at. The ionisation is produced by heating the platinum electrode by an electric current. The current passing between this plate and another metal plate parallel to it is measured for various distances between the plates. Theory gives an equation for the current, from which it appears that (1) the current is independent of the intensity of the ionisation—*i.e.*, of the temperature of the plate—beyond a certain limiting value; (2) the current is directly proportional to the square of the voltage between the plates; (3) the current is directly proportional to the velocity of the ions, and inversely as the cube of the distance between the plates.

Testing these by experiment, the author finds that they are not all fulfilled. The variation of current with voltage, and variation with distance between the plates, are in general agreement with theory, if we make due allowance for differences between the experimental and theoretical conditions. But in the case of (1) above, there are wide discrepancies between the experimental and the theoretical results. These are discussed, and the author shows that they may be satisfactorily explained if we suppose that, above a certain temperature, the current is carried by two or more kinds of carriers, some of which move much more slowly than the others. No definite explanation can as yet be given of the origin of these slow carriers, but two suggest themselves as possible. Since glowing platinum is known to lose weight, due probably to disintegration of the surface, the particles shot off might in their passage, slow compared with that of a free ion, acquire a charge from the ions. On the other hand, there is considerable evidence that in the discharge of electricity by flames of glowing platinum, the ions are of unequal size; whether initially unequal, or becoming so from condensation of matter around

them, cannot be readily determined by experiment. The author finally discusses the velocity of the ions, and shows that the theoretical values cannot be assumed to represent the actual values. Direct measurement shows that the velocity of the positive ions from glowing platinum may, for given conditions, vary within wide limits ; the velocities of the ions increase with increase of temperature of the gas through which they pass ; and the values calculated from the theoretical formula are too small. W. C. H.

869. *Decomposition of Hydrogen Peroxide by Light, and Electrical Discharging Action of this Decomposition.* **R. F. D'Arcy.** (Phil. Mag. 3. pp. 42–52, Jan., 1902.)—The author describes experiments showing (1) that hydrogen peroxide when exposed to sunlight is decomposed, and (2) that a layer of hydrogen peroxide undergoing this decomposition is capable of discharging negative electrification. In the case of positive electrification no clear indications were given. The special form of apparatus employed is described. The discharging effect of hydrogen peroxide is compared with that of water, by using these liquids, under identical conditions, in alternate experiments. The author suggests that when hydrogen peroxide is split up into water and oxygen, the water is positively charged and the oxygen negatively, and that the ions normally present in air may have their origin in this chemical action. The formation of H_2O_2 in nature is a recognised fact, and if the origin of the positive and negative ions be due to its decomposition, the phenomena of atmospheric electricity might be traced to the action of plants, assuming the correctness of the view that to their action is to be attributed the free oxygen of the atmosphere. W. C. H.

870. *Spontaneous Ionisation of Gases.* **C. T. R. Wilson.** (Roy. Soc., Proc. 69. pp. 277–282, Jan. 31, 1902.)—The author gives the results of measurements of the relative rates of production of ions in air and other gases, when contained in a closed vessel, and not exposed to any known ionising agent. The apparatus used was practically the same as that described in the author's earlier paper [see Abstracts Nos. 849 and 1507 (1901)], in which his discovery of this spontaneous ionisation was published. Measurements were made for air, hydrogen, carbonic acid gas, sulphur dioxide, and chloroform. The curves indicating variation of saturation-current with pressure show that, except at the higher pressures, the leak is proportional to the pressure. For those pressures at which the straight-line law holds, and where the rate of leak is a measure of the ionisation, the author gives the following table of "relative ionisations" :—

Gas.	Relative Ionisation, Spontaneous.	Relative Ionisation / Specific Gravity.	Relative Ionisation, produced by radium rays (Strutt).
Air	1·00	1·00	1·00
H_2	0·184	2·7	0·157
CO_2.....	1·69	1·10	1·57
SO_2.....	2·64	1·21	2·32
$ChCl_3$.....	4·7	1·09	4·89

Thus, except in the case of hydrogen, the ionisation is very nearly proportional to the density of the gas. The values of this relative ionisation

occurring spontaneously show a remarkable similarity to those obtained by Strutt [see Abstract No. 1646 (1901)], for the same gases when exposed to the action of radium rays (see last column of above table). The author thinks that an explanation of the results may be found if we suppose the ionisation to be due to a slight radio-activity of the walls of the containing vessel, the radiation being of only moderate penetrating power. The departure from the straight-line law at higher pressures would thus be explained, as at these higher pressures the intensity of the radiation might be reduced by absorption before reaching the centre of the vessel. Further experiments, however, are needed before a definite conclusion can be drawn, that the spontaneous ionisation is due to radio-activity of the walls. W. C. H.

871. *Phosphorus Emanation.* **C. Barus.** (Phil. Mag. 3. pp. 80–91, Jan., 1902.)—In this paper the author concludes his series of papers on the behaviour of phosphorus emanation. [See Abstract No. 58 (1902).] The experiments here described have as their object the determination whether the assumption previously made that, with the conditions chosen (swift-air currents, and highly sensitive ioniser), the decay of the ionisation might be disregarded. For this purpose spherical condensers are used, so that no ions can escape, and the results show—on the whole—that decay due to mutual destruction of ions is not in direct evidence, and may be considered negligible in these investigations. The enclosed air at a distance from the phosphorus rather behaves as if it contained more ions than the number reaching it from the source. The paper ends with a summary of the theory underlying all the investigations. W. C. H.

872. *Determination of Frequency of Slow Electric Vibrations.* **K. E. F. Schmidt.** (Ann. d. Physik, 7. 1. pp. 225–230, Dec., 1901.)—This method is characterised by the use of a telephone to generate stationary acoustic waves in a glass tube. The telephone is excited by the vibrations under examination, and the acoustic waves thus formed are detected and measured by Kundt's dust figures, and also by the lengths which give sounds of maxima and minima intensity. With frequencies of 2,800 an accuracy of 0·1 per cent. was obtained. E. H. B.

873. *Skin Effect in Electrical Oscillators.* **C. A. Chant.** (Amer. Journ. Sci. 13. pp. 1–19, Jan., 1902.)—An account is given of elaborate experiments undertaken to find whether electrical oscillators with very thin surfaces of metal are as efficient as similar ones made solid or with thicker skins. Oscillators of the cylindrical and of the spherical type were used. The cylindrical oscillators were 2·5 cm. in diameter and 12·5 cm. long, the ends being hemispherical. The materials used were respectively solid brass, solid Norway iron, copper tubing 1·5 mm. thick and 0·8 mm. thick, solid electric light carbon, sheet platinum 0·0013 cm. thick on a wooden form, sheet silver 0·002 cm. thick, tin-foil 0·0025 cm. thick on wood, gold leaf 0·0000114 cm. thick on wood, silver leaf 0·00003 cm. thick on wood, copper deposited electrolytically to thicknesses 0·0001, 0·00015, 0·0002, and 0·0005 cm., silver deposited chemically on glass to a thickness of 0·000013 cm. The spherical oscillators were of the Righi pattern. The oscillator spheres were of three sizes, viz., 2·5 cm. in diameter, 4 cm., and 10 cm.; each size was made in solid brass and in gold leaf on wood. The receiver used was a Rutherford magnetic detector. The results are exhibited in seven tables, and show that, in the case of the cylindrical and spherical doublets, the various thin mantles, and even the excessively thin gold-leaf shells were as efficient as the solid metal bodies. E. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

874. *Dielectric Constants of Dilute Electrolytic Solutions.* **A. de Forest Palmer, Jr.** (Phys. Rev. 14. pp. 38–56, Jan., 1902.)—The author describes experiments on comparing the dielectric constants of dilute electrolytic solutions (copper sulphate and potassium chloride) with that of pure distilled water. A pair of Leyden jars on insulating stands have their outer coatings connected to a spark-gap and induction coil, their inner coatings to a pair of parallel copper wires of about 8 metres in length, on which a wire bridge is arranged to slide. Two identical quadrant electrometers of the cylindrical type have one pair of quadrants, the needle and brass case connected together, and to a point on one of the wires about $2\frac{1}{2}$ metres from the inner coating of the Leyden jar; the other pairs of quadrants, which are insulated from the case, are also connected together, and to a point on the other wire equidistant from the coating of the jar to which it is attached. The electrometers are respectively filled with the solutions to be compared. When the coil is in action the frequency of the Hertzian vibrations is about 10^6 per second, and the needles of the electrometers are deflected, the amount of the deflection being controlled by the position of the wire bridge. The spots of light of the electrometers are then brought to their zeros, by turning torsion heads to which the needles are attached (the zero position being the ones in which the needles are symmetrically situated with regard to the quadrants), and the induction coil stopped, the resulting deflections observed, and from these deflections can be deduced the ratio between the dielectric constants of the two solutions used. The results obtained show it is highly probable that the dielectric constant of dilute electrolytic solutions, of conductivity less than $2{\cdot}5 \times 10^{-4}$ ohms per centimetre cube is the same as that of pure water in fields varying at the rate of 10^5 oscillations per second. E. C. R.

875. *Variation of the Dielectric Constant of Caoutchouc by Stretching.* **G. Ercolini.** (N. Cimento, 2. pp. 297–301, Nov.–Dec., 1901.)—According to theory, if the electrical deformation of a condenser is such that its internal volume and its length increase, then the dielectric constant of the solid isotropic dielectric should increase when it is subjected to mechanical tension. For glass the author has previously [see Abstract No. 464 (1899)] shown this to be the case, but with caoutchouc, Corbino and Cannizzo [see Abstract No. 571 (1899)] found that stretching causes a diminution of the dielectric constant. The results of these last-named workers are, however, indecisive, since the author now finds that, like india-rubber [see Abstract No. 2142 (1901)], caoutchouc also undergoes strong electrification when stretched.

T. H. P.

876. *Thermoelectric Power of Steels and Nickel-steels.* **G. Belloc.** (Comptes Rendus, 134. pp. 105–106, Jan. 13, 1902.)—This is a continuation of previous work on soft iron and steel [see Abstract No. 2217 (1900)], with an extension to nickel-steels containing from 5 to 35·5 per cent. of nickel. The result is that the (dE/dt, t) curve has a minimum about 380°, a maximum between 660° and 870°, depending on the composition, and another minimum about 120° above the maximum. H. Le Chatelier has found similar results in the variation of resistance with temperature. For the nickel-steels the curves do not progress with the chemical composition as with the steels; the general form of the (E, t) curves for nickel-steel platinum couples is parabolic excepting that for the 5 per cent. nickel; the 5 and 28 per cent. nickel-steels showed

sudden variations above 400° and 500°, pointing to some molecular change; the 28 per cent. nickel-steel has great thermoelectric power and high neutral point; and small variations in the amount of nickel cause large changes in thermoelectric power, as shown in the table below:—

Percentage of Nickel.	Neutral Temp.	E in Microvolts at 196° to 400°.
5	—	—
24	250	980
26	60	70
28	495	6,300
30·4	95	120
34·6	190	1,050
35·2	84	112
35·5	150	616

G. E. A.

877. *Measurement of Potential.* **C. Carpini.** (Accad. Lincei, Atti, 11. pp. 65–69, Jan. 19, 1902.)—The paper contains a discussion of the method of measuring high potentials by observing the deformations of a liquid surface (mercury in tubes of known diameter). The results obtained are very favourable. A. D.

878. *Hall Effect in Liquids.* **P. Moretto.** (N. Cimento, 5. pp. 80–84, Jan., 1902.)—The alkalimetric method previously used with success in studying the Hall effect in solids [see Abstract No. 2032 (1900)] is extended to the investigation of the Hall effect in liquids. Negative results were obtained throughout, even with bismuth amalgam. A. D.

879. *The Induction Coil.* **Rayleigh.** (Archives Néerlandaises, 6. pp. 197–211, 1901, and Phil. Mag. 2. pp. 581–594, Dec., 1901.)—The complications in the theory of the induction coil are due mainly to (1) the departure of the iron from theoretical behaviour, whether due to circumferential eddy-currents or to a failure of proportionality between magnetism and magnetising force; (2) the departure of the break from the ideal of an instantaneous abolition of the primary current; (3) the capacity of the secondary, in virtue of which the currents need not, at any moment, be equal throughout. On the assumptions of ideal iron, instantaneous break, and no secondary capacity, Maxwell has given a complete solution (Scientific Papers, 1. p. 546). Making the first two assumptions, and treating the secondary as a condenser with oscillatory current, let q be the capacity at the secondary terminals, V the maximum p.d., L the coefficient of self-induction of the primary circuit, and c the current in the primary just before breaking. Then the energy of the charge is qV^2, and this can never exceed the energy of the primary current before break, viz., $\frac{1}{2}Lc^2$, so that the limiting value of V is $V = c\sqrt{(L/q)}$, which is proportional to the primary current. When the core is long and narrow, or forms a nearly closed circuit, the behaviour of the iron may differ widely from the ideal. The author arrived some years ago at the conclusion (Phil. Mag. 22. p. 175, 1886) that, on the theory of Warburg and Hopkinson, the bodily magnetisation of the iron does not, as is generally supposed, represent a large store of available energy. If the core is treated as an elongated ellipsoid of revolution, with magnetisation I parallel to its longest axis, due to an external magnetising force H parallel to the same axis, then the demagnetising effect of I will be NI, where N is a function of the eccentricity, and the operative magnetising force H will be given by the equation $H = H' - NI$, and the work

expended in magnetising unit volume of the iron will be $\int H dI + \frac{1}{2}NI^2$, reckoning from the condition of zero magnetisation. The first part of this is practically wasted, while the second, which in most cases of open magnetic circuits is much the larger, is recovered on demagnetisation. Taking 1700 c.g.s. as the maximum value of I, the maximum energy, where v is the volume of the core, is $\frac{1}{2}Nv \times 1700^2$, and equating this to $\frac{1}{2}qV^2$ gives (in electrostatic measure) as a limiting value for V, $V = 1700\sqrt{(Nv/q)}$. This gave $V = 2600$ for a coil in the author's possession constructed to give an 8 to 10 cm. spark when new. Reckoning 33,000 volts to the cm., this would give 24 cm. as the calculated limit to the spark-length, and, considering that the limit is fixed by the iron and secondary capacity only, the smallness of its excess over the actual capability of the coil is noteworthy. The effect of suddenness of break is then considered, and it is shown, supposing the behaviour of the iron to be ideal, in which case the secondary circuit may be treated as a simple vibration subject to a force proportional to the rate of fall of the primary current, that a reduction in the number of windings, and the accompanying diminution in the time of oscillation, would necessitate greater suddenness of break, in order to maintain the spark-length. Theoretically it is difficult to see that any advantage can be derived from a condenser, except increased suddenness of break. Except for this effect, the increase of capacity would diminish the spark-length. The author has confirmed these theoretical conclusions by experiments in which the primary circuit was broken with great suddenness by means, first of a pistol bullet, and then of one fired from a service rifle, and it was found that a greater spark-length was obtained in this way than with a condenser, and the addition of a condenser in conjunction with this quick break diminished it. These experiments strongly support the view that the only use of a condenser, in conjunction with an ordinary break, is to quicken it by impeding the development of an arc, so that, when a sufficient rapidity can be obtained by other means, the condenser is deleterious, prolonging, in fact, the decay of the primary current.

The author's conclusions with respect to the design of induction coils are that (1) there should be sufficient energy at break, and therefore a considerable mass of iron, well magnetised, and not forming a circuit too nearly closed; (2) the obstacles to the full utilisation of this energy are want of suddenness in the break, eddy-current in the iron, and (in respect of spark-length) capacity in the secondary; (3) in a well-designed coil these impedimenta should operate somewhat equally. G. W. DE T.

880. *An Absolute Electrometer. Measurement of the Potential of Discharge.* **E. Pasquini.** (N. Cimento, 2. pp. 302–312, Nov.–Dec., 1901.)—The electrometer described in detail by the author is essentially an absolute electrometer with a guard-ring, the measurement of the force of attraction between the fixed plate and the movable disc being made by means of the equilibrium of floating bodies. Results are given of a number of experiments made with the instrument, which yields very concordant numbers. T. H. P.

881. *Volta E.M.F. in Electrometers.* **W. Duane.** (Phys. Rev. 13. pp. 369–377, Dec., 1901.)—The author shows that the Volta e.m.f., due to the contact between dissimilar metals, may introduce considerable error in measurement by electrometers. If, in a quadrant electrometer, V_1, V_2, V_n, are respectively the potentials of the two pairs of quadrants and the needle, the

forces of attraction and repulsion will depend on $V_1 + \phi_1$, $V_2 + \phi_2$, and $V_n + \phi_n$, where ϕ_1, ϕ_2, ϕ_n are the rises of potential in passing from the metals to the air just outside. When the electrometer is used heterostatically these Volta e.m.f.'s introduce no error, as they are taken into account in the zero of the instrument. When used idiostatically $V_n = V_1 + \phi_{1n}$ and $\phi_1 = \phi_2$, and for the usual formula must be substituted—

$$\theta = k(V_1 - V_2)\{V_1 - V_2 + 2(\phi_n + \phi_{1n} - \phi_1)\}.$$

Tests made on an electrometer with brass quadrants and aluminium needle showed a difference of 5 mm. in a deflection of 275 mm. on reversing the e.m.f. After cleaning the needle with emery-cloth the difference was increased to 26 mm. Methods of measuring the effect are described.

G. H. B.

882. *Oscillometer for Measuring the Current and Oscillations in a Secondary Circuit.* **G. Bowron.** (Roentgen Ray, Archives, 6. pp. 11–12, Aug., 1901.)—The discharge from a static machine or induction coil may be more or less oscillating or alternating. The author couples in series a gravity milliamperemeter and a permanent magnet direct-current milliamperemeter ; the former gives the sum of the direct current and the superposed oscillations, the latter their difference. A. D.

883. *Rectifier.* **G. B. Batten.** (Roentgen Ray, Archives, 6. pp. 12–16, Aug., 1901.)—An armature oscillating between constant and alternating poles actuates a spring which makes contacts, through which pass two alternately interrupted currents. Sparking is prevented through introducing a retardation of phase by a transformer, and accelerating the phase of the driving current by a condenser in shunt across a resistance. The apparatus is self-starting, self-acting, small and compact, and is suited to single-phase alternating machine currents of any voltage and any periodicity. A. D.

ALTERNATING CURRENTS AND MAGNETISM.

884. *Energy Dissipated in Dielectrics in an Alternating Electric Field.* **P. L. Mercanton.** (Journ. de Physique, 1. pp. 33–39, Jan., 1902.)—Condensers formed by plates of dielectrics to be experimented on of 3 to 4 mm. in thickness were submitted to cyclic changes in the potential difference applied to their terminals, the frequency of which could be varied. Arrangements were made for disconnecting the condenser at any point of the cycle, and discharging it through a ballistic galvanometer. Curves similar to the magnetic hysteresis curve for iron were thus obtained, and the area enclosed by the curve was proportional to the energy consumed in the dielectric. Condensers were formed of plates of pure paraffin wax, with which were incorporated various substances with conducting, insulating, or poorly conducting properties. The following results were obtained, with periodic time = 1 sec. and V_{max} between 63 and 88 volts. The loss of energy was found to be inappreciable in the case of pure paraffin ; of paraffin mixed with 4·7 per cent. of powdered aluminium, 4·4 per cent. of powdered arc lamp carbon, 5·4 per cent. of graphite, 50·0 per cent. of resin, or with 10, 20, or 30 per cent. of sulphur ; Berthoud, Borel & Co.'s insulating compound ; a mixture of dry pine sawdust and paraffin ; a large lamina of white mica 0·10 mm. thick ; paraffin wax containing 50 per cent. of resin, and Berthoud's compound

superposed. This last experiment was tried to verify the allegation of Muraoka that two dielectrics, each without hysteresis, produce a residual charge when superposed, but the result was negative.

Various liquids contained in a flat trough into which were plunged metal plates were experimented on. Pure vaseline oil gave no loss, but when mixed with 5·9 per cent. of crude lampblack a considerable loss was observed, the ratio ρ of the throw on the ballistic galvanometer corresponding to zero potential, to the throw when the potential is a maximum, having the value 0·07. For celluloid and window-glass the values of ρ were 0·065 and 0·038 respectively. In the case of paraffin wax containing 1, 2·5, 5, and 9·4 per cent. of lampblack respectively, the values found for ρ were 0·013, 0·073, 0·260, and 0·380. Mechanical vibration of the dielectric while charging made no sensible difference in the loss of energy. Experiments were made on a paraffin wax condenser containing 9·4 per cent. of crude lampblack as to the connection between W, the loss of energy due to hysteresis, and T, the periodic time of a cycle, the values of T being taken from 0·25 sec. to 50 secs. at values of V_{max} 19, 36 and 73·8 volts. In each of the three cases a very marked maximum of W is shown for $T = 3$. When plotted as curves with W as ordinates and T as abscissæ, the curve is asymptotic to the axis of abscissæ for large values of T, and for small values it bends rapidly towards the origin. For $T = 1$ sec., and V_{max} 16·7, 34, and 68 volts respectively. The values of W were $77{\cdot}5 \times 10^{-10}$, 410×10^{-10}, and 2052×10^{-10}, W being measured in joules per cubic centimetre per cycle. With $T = 20$ secs., and V_{max} having the values 34 volts and 68 volts respectively, the values of W were 266×10^{-10} and 1380×10^{-10}. E. C. R.

885. *Wave-forms in Three-phase Systems.* **A. Russell.** (Electrician, 48. pp. 487–489, Jan. 17, 1902.)—The author discusses the effect on three-phase circuits of a wave-form differing from the sine curve. In the case of a balanced star-connected circuit it is shown that, if f be the frequency of the currents in the outer conductors, a current will pass in the neutral wire, having a frequency $3(2n+1)f$, where n is a positive integer. The lowest frequency for the current in the middle wire is therefore $3f$. It is shown that the load on a three-phase generator symmetrically loaded but giving non-sinusoidal current fluctuates with a frequency $6f$, and that the angular velocity and intensity of a rotating field produced by such currents likewise vary with this frequency. A. E. L.

886. *Measurement of Magnetic Hysteresis.* **G. F. C. Searle** and **T. G. Bedford.** (Roy. Soc., Phil. Trans. 198. pp. 33–104, Jan. 31, 1902. Roy. Soc., Proc. 68. pp. 348–352, July 9, 1901) (Abstract.)—The paper describes in detail the method employed to measure the energy spent in hysteresis, and gives the results of numerous measurements showing the relations between hysteresis loss and tension and torsion in iron and steel wires. The energy spent in a reversal of the magnetising current is measured by a ballistic dynamometer, the magnetising current passing through the fixed coils, while the induced current from a secondary winding passes through the suspended coil. The dynamometer was calibrated by an earth inductor. The theory of the method is developed very fully, and terms are introduced representing the losses of energy in eddy-currents and in the secondary circuit. These can be determined by observations with different resistances in circuit. As they depend on the rate of change of the magnetising current, the reversal of this must be effected gradually, for which reason a highly

inductive coil is included in the primary circuit, and a reversing key of special design is used, which introduces resistance before reversing.

Comparisons were made showing satisfactory agreement between the hysteresis loss as measured by the ballistic dynamometer and that calculated from the B-H curves obtained by a ballistic galvanometer. Simultaneous measurements of B and the hysteresis loss were made by using the ballistic galvanometer and the dynamometer.

In freshly annealed iron wire both B and the hysteresis loss were found to decrease with repeated reversals, the latter showing the greater change. Both are sensibly constant after some 40 cycles, and the change is less the stronger the field. The effect of tension is to increase B and the hysteresis to a maximum, and then to diminish them. Torsion causes both to decrease Curves are plotted between B and the hysteresis loss for constant field strength, the variations being due to torsion or tension; from these an equation is derived expressing the hysteresis loss in terms of B and H; it is of the form, $W = a \cdot B\sqrt{H} + b$. The hysteresis loss was found to diminish when a current was passed through the wire; a current of 1·12 amperes in a wire 1 mm. in diameter decreased the hysteresis loss by 22·7 per cent. This is probably due to circular magnetisation by the current.

Two appendices are attached; the first treats mathematically of the heat produced by eddy-currents in rods of circular and rectangular sections; the second deals with the demagnetising force due to rods of finite length. As H was increased, the demagnetising force h increased to a maximum and then diminished to a minimum, and for high values of H was less than that which would obtain if the lines of induction issued only from the end surfaces. This small value of h implies the existence of poles between the centre and ends of the wire, due to non-uniformity in the wire caused by hysteresis. G. H. B.

887. *Distribution of Lines of Magnetic Induction.* **V. Karpen.** (Comptes Rendus, 134. pp. 88–90, Jan. 13, 1902.)—An approximate or arbitrary distribution of the lines of induction may be considered as a real distribution by supposing that the boundaries of the tubes of induction are impermeable to the lines of force. It may then be said that to each distribution there corresponds a certain intrinsic energy of the medium, and under these conditions the following principle may be enunciated: In a magnetic medium submitted to the action of a certain number of magnetomotive forces the course of the lines of induction is such that the intrinsic energy of the medium is a maximum. Let $\varepsilon, \varepsilon', \ldots$ be the magnetomotive forces acting, $\phi, \phi' \ldots$ the fluxes traversing these magnetomotive forces; then the intrinsic energy of the medium will be—

$$W = \frac{1}{8\pi}(K\varepsilon\phi + K'\varepsilon'\phi' + \ldots)$$

$K, K', \ldots$ being coefficients less than unity. The course of the lines of induction must be so chosen as to make this expression a maximum. If, as often happens, there is only one magnetomotive force, the flux traversing it must be a maximum, or, what comes to the same thing, the reluctance must be a minimum. J. J. S.

888. *Formulæ for Magnetisation Curves.* **E. Müllendorff.** (Elektrotechn. Zeitschr. 23. pp. 25–28, Jan. 9, 1902.)—On theoretical grounds the author

proposes the following two formulæ to represent the relation between magnetising force H and magnetic induction B—

$$B = ae^{-\frac{\beta}{H^{\mu}}} + H \quad \text{.....(1)}$$

and—

$$B = a\left\{1 - \frac{1}{(1 + bH^{m})^{n}}\right\} + H \quad \text{.....(2)}$$

The author discusses the means of determining the constants a, β, μ, b, m, and n from a suitable number of points on an experimental curve—a being strictly speaking the maximum value of B. To obtain more accurate results over a given length of curve, however, it is preferable to give a value found from that part—not necessarily corresponding to the extreme suturation. Both expressions give the concave part of the curve of initial magnetisation, being tangential to the axis of x at the origin, and having as asymptotes the saturation line a. Results are tabulated for curves given by Kapp for cast iron, wrought iron, mild steel, and armature sheet. The maximum differences between the observed values and those obtained by the two formulæ are as follows :—

	Cast Iron.	Wrought Iron.	Mild Steel.	Armature Sheet.
Formula (1)	7·3%	0·9%	1·5%	2·0%
Formula (2)	5·4%	1·5%	1·5%	2·0%

The difference in accuracy between the two formulæ is so small that Formula (1) is to be preferred on account of its greater simplicity. A. E. L.

889. *Behaviour of the Coherer in the Magnetic Field.* **E. Drago.** (N. Cimento, 2. pp. 319–321, Nov.–Dec., 1901.)—It has been shown by Opler (L'Elettricità, 1898, p. 29) that a tube containing iron filings, arranged axially between the poles of an electromagnet, acquires appreciable conductivity at the instant the magnetic field is created. The author describes similar experiments with an ordinary coherer containing powdered bismuth, the results of which show that the resistance of contact of such a coherer either remains unchanged under the action of the magnetic field, or else the changes are so small as to be masked by Righi's phenomenon. T. H. P.

890. *Magnetisation Constants of the Rare Earths.* **S. Meyer.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 541–559, May and June, 1901. From the Physical Institute of the University of Vienna.)—The author gives his determinations of the magnetisation constants of the rare earths in a series of tables. If we arrange the metals in order of increasing atomic weight, we have the following values for the "molecular magnetism," K :—

	Y	La	Ce
$K \cdot 10^6 =$	(diamagnetic)	−0·23	+0·06.

	Pr	Nd	Sa	Gd	Ho	Er	Yb
$K \cdot 10^6 =$	3·3	5·2	11·2	27·3	50	38·2	6

The analogy with the iron group of the periodic table is unmistakable :—

	V	Cr	Mn	Fe	Co	Ni
$K \cdot 10^6 =$	1·3	6·3	15	12·5	10	5

D. H. J.

891. *Types of Terrestrial Magnetism.* **N. Umow.** (Soc. Imp. Nat. Moscou, Bull. 1. 2. pp. 1–72, 1902.)—The writer supposes a vector having arbitrarily assigned values at each point on a spherical surface. Taking for axis the diameter NS of the sphere, the components of that vector are X in the meridian, Y along a parallel of latitude, Z vertical. Consider the parallels of latitude u, u_1. At every point in the parallel u the resultant of X and Z may be produced till it cuts the plane of the parallel u_1. This being done for all values of u, the points of intersection of these resultants with the plane u_1 form an image on that plane of the vector distribution over the surface. If u be very near to u_1, then generally the image of the vectors on u is the circle u_1 itself. But an exception occurs when the resultant of X and Z for the circle u_1 lies in the plane of that circle. In that case the limiting position of the intersection with the u_1 plane of the resultant of X and Z for u, as u approaches u_1, may not be on the circle u_1. A parallel of latitude for which the resultants of X and Z are in the plane of the parallel is defined to be a *critical plane* of the type of vector distribution in question, and u_1 is the *critical angle*. An example is given, viz., a uniformly magnetised sphere. It is found that this distribution or type has two critical planes corresponding respectively to north and south latitudes $\cos^{-1}(\sqrt{3})^{-1}$. The above being the mathematical method, the writer considers a regular type of magnetisation which in its principal features resembles that of the earth, and supposes an image of the actual magnetisation to be formed on the critical planes of this regular type. Making use of Leyst's work "on the geographical distribution of normal and abnormal magnetism" (Moscow, 1899), he gives a table of the south to north components of magnetic force on Mercator's projection, and arrives at the conclusion that the best image of these is the image formed on the critical planes of the uniformly magnetised sphere, namely, latitudes $\pm\cos^{-1}(\sqrt{3})^{-1}$. In his second part the writer considers the possible magnetic types of an arbitrarily magnetised sphere, and shows that every distribution has a special or fundamental type and residual types. The mathematics of this part of the work cannot be given in an abstract. In the third part the investigation is applied to the special case of the earth on the foundation of Gauss' potentials, as calculated by Neumayer and Petersen. It is found that the fundamental type of the earth's magnetisation is that of a uniformly magnetised sphere. On this certain other types are superimposed, in particular one whose axis lies in the equatorial plane, here called the east-west distribution. S. H. B.

ELECTROPHYSIOLOGY.

892. *Independence of Closely Connected Functions of Muscle Fibre.* **T. W. Engelmann.** (Archives Néerlandaises, 6. pp. 689–694, 1901.)—The movement of a muscle depends on the simultaneous operation of three functional properties of its constituent elements, *i.e.*, excitability, conductibility, and contractibility. By the first of these is meant the faculty of such an element when excited of becoming active, which is indicated by the appearance of electric currents (action currents), and followed, after a short interval, during which the energy remains latent, by the mechanical process of contraction. Excitability is measured by the inverse ratio of the value of the most feeble excitation sufficing to produce a perceptible irritation, *i.e.*, the inverse of the threshold value (Schwellenwerth). Under normal circumstances this process of activity or of irritation is communicated by waves to neighbouring muscle constituents, even before contraction begins, and extends as far as there

exists a physiological contact between such excitable muscle constituents or elements. The measure of conductibility is given by the velocity which characterises the process of inter-communication, while contractibility, finally, is measured by its mechanical equivalent. Notwithstanding the close connection between these functions referred to, however, they are, up to a certain point, independent of each other, and, under certain conditions, one of them may be entirely suspended while the others remain in full activity. The author describes as *bathmotropic* (from $\beta\acute{\alpha}\theta\mu o\varsigma$ = threshold) such influences as affect excitability, as *dromotropic* such as interfere with conductibility, and as *inotropic* such as lessen or destroy contractibility. The independence especially of conductibility is very striking, and has been known for a long time. Thus under certain circumstances, for instance, owing to the stoppage of circulation, conductibility may be reduced in the muscle fibres to zero, and yet a direct and primary act of an excitant may still provoke powerful "idiomuscular contractions." As a case in point it may be stated that water, as was discovered by W. Biedermann, may destroy entirely, or nearly so, the contractibility of an ordinary muscle (Sartorius) without producing any perceptible bathmotropic or dromotropic effect. The author who has experimentally studied especially bathmotropic influence, exercised both upon ordinary striated muscles, which are under the control of the will, and upon ventricles and auricles, and has already published some of the facts discovered by him, adds in this paper some new data. Thus he points out that when the commencement of a portion of the sartorius of a frog was inoculated with curare, after this portion had been dilated in water and deprived of its contractibility, without having lost either its excitability or conductibility, the threshold of excitation (Reizschwelle) was often not sensibly diminished.

Experiments made with reference to the heart showed similar results. In many such cases the velocity of transmission of the motive power in a portion of the sartorius or in the heart, which had been deprived of contractibility, was not diminished and occasionally was even increased, thus producing a positive dromotropic effect side by side with a negative inotropic effect. Nuel discovered that the action of the vagus not only diminishes the frequency of the cardiac contractions, but also the intensity of the systoles. Schiff and Eckhard, and, more recently, McWilliam and W. Mills, have demonstrated that excitation of the pneumogastric causes the ventricles and auricles to lose their direct excitability by means of electricity. The author's experiments have confirmed this fact in so far as they have shown that the heart, or at least its auricle, can be made to remain for a very short time passive to electrical or mechanical excitation by a strong excitation of the pneumogastric, but he maintains that the excitability of the auricle very soon returns to its normal condition—in fact, long before the diminution or total stoppage of its contractibility has ceased. The new facts discovered by the author confirm, in his opinion, his theory that the physiological process of irritation indicated by the so-called "action-currents," is linked to other constituents of the muscle than the mechanical process of contraction; otherwise their independence of each other would be incomprehensible. The question therefore arises whether the microscope may reveal to us the difference of these hypothetical constituents, or whether their difference lies beyond our limits of visual perception. The author has elsewhere (Archives Néerlandaises, (1), 27, 65, 1893), stated his reasons for assuming that the physiological effect indicated by the appearance of electric currents is linked to the birefringent portions of muscle fibre, while the mechanical effect of contractibility is linked to the monorefringent portions, and thinks that the result of his recent experiments strengthens his theory.

G. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

893. *Decomposition of Acetylene during Combustion.* **F. Gaud.** (Comptes Rendus, 134. pp. 175–177, Jan. 20, 1902.)—The author finds that with a Manchester acetylene burner there is very little fouling during use with the usual gas pressure. When the passage of gas is very slow, however, fouling of the cup of the burner soon occurs, though the supply channels remain, even in this case, quite unobstructed. Bullier attributed the fouling to the formation and subsequent decomposition within the burner of polymers of acetylene. Now decomposition of acetylene occurs at temperatures of 100° and upwards. The author accordingly shows from measurements of the temperature of the gas just previous to its combustion, that this temperature rises above 100° when the passage of the gas is slow, but falls below 100° with a rapid current of gas. D. H. J.

894. *Pure Fused Lime.* **H. Moissan.** (Comptes Rendus, 134. pp. 136–142, Jan. 20, 1902.)—The author finds that pure lime does not fuse at the blowpipe with mixtures of acetylene and oxygen, or of carbonic oxide and oxygen, and, in the case of mixtures of hydrogen and oxygen, fusion only occurs when the gases are present in the proportion of 2 vols. of hydrogen to 1 of oxygen. Lime is much more readily fused in the electric furnace. After the fusion, part of the lime is obtained in crystals belonging to the regular system; these crystals appear to change on keeping to crystals belonging to a less symmetrical system. Non-crystalline lime has a specific gravity of 3·3, the regular crystals a specific gravity of 3·4; so that here, as in the case of magnesia, we have evidence of polymerisation. The heat of neutralisation is the same for the different varieties of lime. Fused lime was found to readily oxidise iron, manganese, nickel, cobalt, boron, silicon and titanium.

D. H. J.

895. *Polymorphism and Isomerism.* **R. Wegscheider.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 907–928, July, 1901. Aus dem chemischen Laboratorium der k.k. Universität in Wien.)—The author concludes that the distinction between polymorphism and isomerism is serviceable, though no sharp boundary between the two exists, and points out various things that serve to differentiate the one from the other. Thus, for example, isomerism is shown by differences occurring in the products of fusion, solution, or evaporation, or by differences in derived substances; it is in isomerism that the stable form in the neighbourhood of the melting-point has a lower melting-point than the labile form; it is in isomerism that the more stable solid under the given conditions has the greater solubility or the greater vapour pressure; and isomerism is probable if both solids form the same compound with very different reaction-velocities, or if in super-saturated solutions the super-saturation is removed with very different velocities.

W. C. T.

896. *Simultaneous Equilibrium of Homogeneous Systems.* **R. Wegscheider.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 561–618, May and June, 1901. Aus dem chemischen Laboratorium der k.k. Universität in Wien. Also Zeitschr

Phys. Chem. 39. pp. 257–303, Dec. 13, 1901.)—This paper deals with the chemical kinetics and statics of homogeneous systems, particularly in cases in which several reactions leading to equilibrium occur together. Exception is taken to Euler's theory of catalysis and the connection deduced by him between the equilibrium coefficients and the velocity constants (Ber. der Deutschen chem. Gesellsch., xxxiii. 3202, 1900), in that it involves the assumption that dissociation-equilibrium occurs instantaneously for an ester, water, acid, and alcohol. The author shows how in general the conditions of equilibrium may be derived from the laws of kinetics, taking as an example the reciprocal transmutation of three isomers, for which case the relation between the equilibrium coefficients and the velocity constants is derived, and it is shown that the pairs of reactions would be only in equilibrium, as well separately as together, if a determined relation existed between the velocity constants. It is shown that sometimes the conditions of equilibrium given by kinetics do not agree with those given by ordinary thermodynamics, the concentration ratios, according to thermodynamics, being independent of the total concentration, but according to kinetics, depending on it. The conditions under which this contradiction occurs are discussed, and it is suggested that it may be due to the equilibrium being then a stationary transmutation rather than equilibrium in the mechanical sense. The contradiction also disappears if one assumes in the thermodynamic derivation of the condition of equilibrium either that the variations occurring in the molecule numbers are not solely limited by stoichiometric conditions, or that the velocity constants in simultaneous reactions are not in general independent of one another. A similar contradiction also occurs in reference to catalysis.

W. E. T.

897. *Simple Proof of Gibbs' Phase-rule.* **Kuenen.** (Roy. Soc. Edinburgh, Proc. 23. pp. 314–318, July, 1901.)—This proof, for which the author does not claim originality, depends on the assertion that for a system in equilibrium there must be an equation to be satisfied by the variables for every independent virtual reaction in the system. F. G. D.

898. *Change of Coefficient of Absorption of a Gas in a Liquid with Temperature.* **Kuenen.** (Roy. Soc. Edinburgh, Proc. 23. pp. 312–316, July, 1901.)—The solubility of a gas in a liquid is considered from the general point of view of the condensation of binary mixtures. The coefficient of absorption is defined as "the rate at which the mass of the gas is absorbed by unit mass of the liquid per unit partial pressure," where partial pressure = pressure of liquid mixture — vapour pressure of solvent. It is shown that a minimum must exist in the expression for the coefficient of absorption as a function of the temperature. For very soluble gases this minimum will probably occur at relatively high temperatures not far from the critical point, but for sparingly soluble gases it may occur at comparatively low temperatures, as found by Estreicher for the solubility of helium in water. F. G. D.

899. *Inorganic Ferments.* **D. McIntosh.** (Journ. Phys. Chem. 6. pp. 15–44, Jan., 1902.)—Colloidal silver or mercury, prepared by sparking the metal under water, decompose hydrogen peroxide in acid or neutral solutions, the metal gradually becoming dissolved, when the action ceases. The same effect is produced very rapidly in presence of alkalies, and is facilitated by rise of temperature, though not by light. T. M. L.

900. *Action of Silver Salts on Ammonium Persulphate Solution.* **H. Marshall.** (Roy. Soc. Edinburgh, Proc. 23. pp. 163–168, Jan., 1901.)—Solutions of potassium persulphate and silver nitrate, when mixed, yield a black precipitate of silver peroxide, which is probably formed by the hydrolysis of the silver persulphate produced. On replacing the potassium persulphate by the ammonium salt only slight precipitation of silver peroxide occurs, but the decomposition of the persulphate is shown by the formation of sulphate and free sulphuric acid. When ammonia is added to the mixed solutions of ammonium persulphate and silver salt there is no deposition of silver peroxide, which is used in the oxidation of the ammonia to nitrogen, large volumes of which are rapidly evolved. The action of the silver salt is a catalytic one, and a small quantity of it is capable of causing the interaction of large amounts of ammonium persulphate and ammonia, according to the equation: $3(NH_4)_2S_2O_8 + 8NH_3 = 6(NH_4)_2SO_4 + N_2$. In aqueous solution and in presence of silver salts ammonium persulphate slowly decomposes as follows: $8(NH_4)_2S_2O_8 + 6H_2O = 7(NH_4)_2SO_4 + 9H_2SO_4 + 2HNO_3$; for moderate concentrations the rate of decomposition is practically proportional to the amount of persulphate present. T. H. P.

901. *Solution of Metals.* 1. **T. Ericson-Aurén** and **W. Palmaer.** (Öfvers. Kongl. Vet. Aked. Stockholm, Förh. No. 7. 58. pp. 525–543, 1901.)—The authors endeavour to explain the solution of metals by investigating the simple case of the velocity of solution of zinc in dilute acids. Having shown that the law of mass action, as employed in the ordinary way, does not explain the experimental results, they maintain that they may easily be interpreted by assuming that the solution of metals is due to local galvanic currents, the slow solution of pure metals being a consequence of this theory. A special formula is deduced for the velocity of solution of zinc containing lead, the results of experiments agreeing most satisfactorily with the calculated ones. The authors then establish the following general formula for the velocity of solution ρ of a metal:—

$$\rho = f \cdot \frac{n}{c}\left\{\frac{0{\cdot}0576}{n}\log\frac{P_1}{p_1} - 0{\cdot}0576\log\frac{P_2}{p_2} - \pi\right\},$$

n being the valency of the metal, P_1 the pressure of solution, p_1 the osmotic pressure of the metal, P_1 and p_2 the same for hydrogen, π the excess of pressure due to metallic impurities, f a constant, n the conductivity of solution, and c the capacity of resistance of the system. This formula is discussed, and its possible application is pointed out. The theory of local currents accounts easily for the slightness of the effect of temperature on the phenomenon, and enables the catalytic effect of impurities to be calculated. Further experiments are in progress. A. G.

902. *Solubility of Potassium Hydroxide in Water.* **P. Ferchland.** (Zeitschr. Anorg. Chem. 30. 1. pp. 130–134, 1902.)—In spite of the practical importance of potassium hydroxide, both for pure and applied chemistry, most contradictory data are current as to its physical constants. The author maintains that the values given by treatises and tables for the solubility in water are all erroneous, and that the only reliable values for the density of potassium hydroxide are those obtained by extrapolation from Pickering's density measurements on solutions of caustic potash. With regard to the maximum concentration, the author points out that the necessity of a superior

limit of 61 per cent. is shown by the existence of the hydrate $KOH, 2H_2O$, while it is a fact known to technical chemists that caustic potash of the density 1·53, as employed in the arts and manufactures, crystallises out readily on being exposed to winter temperatures, 50 per cent. being thus an inferior limit of solubility. He then proceeds to give an account of his own investigations on pure potassium hydroxide obtained by decomposing electrolytic potassium amalgam by a reversed current. After heating the 50 per cent. hydroxide solution in a closed silver vessel to the boiling-point (150°), and then cooling the vessel in cold water, the solution is placed in a thermostat, the hydrate above mentioned separating out in big crystals. Weighed quantities of the mother-liquor are next converted into potassium chloride, in order to analyse the solutions, the densities being ascertained by pycnometrical measurements.

The author deduces for the solution saturated at 15° the density 1·5355 (the unit being that of water at 4°), and a concentration of 51·7 per cent., in satisfactory agreement with the results obtained by extrapolation from Pickering's data. A. G.

903. *Nitriles as Solvents in Molecular Weight Determinations.* **L. Kahlenberg.** (Journ. Phys. Chem. 6. pp. 45–49, Jan., 1902.)—The molecular elevation of the boiling-point of benzonitrile as calculated from the latent heat of evaporation is 48·67, whilst Werner from the elevation of the boiling-point by diphenylamine obtained a value 36·5, assuming this substance to have its normal molecular weight. Taking the former value, evidence of polymerisation was obtained in solutions in benzonitrile of diphenylamine, mercuric chloride and iodide, and silver nitrate. The molecular elevation of the boiling-point of acetonitrile is calculated to be 14·5. Taking this value for the constant, molecular weight determinations gave slightly high values for naphthalene (143 for 128), and diphenyl (171 for 154), and low values for diphenylamine (125 for 169) and silver nitrate (135 for 170).

The low values for diphenylamine in acetonitrile correspond with those for silver nitrate, which gives an electrolytic solution, whilst diphenylamine is not an electrolyte. The high values for electrolytic solutions of mercuric chloride and iodide and silver nitrate in benzonitrile do not give any direct indication of electrolytic dissociation, but are in no way abnormal. T. M. L.

904. *Behaviour of Molecular Compounds in Solution.* **G. Bodländer and R. Fittig.** (Zeitschr. Phys. Chem. 39. pp. 597–612, Jan. 31, 1902.)—From solubility determinations and from the e.m.f. of concentration-cells the conclusion is drawn that a solution of silver chloride in ammonia contains the compound $AgCl, 2NH_3$, and that this is dissociated in solution into the ions $\overset{+}{Ag}(NH_3)_2$ and $\overset{-}{Cl}$, and only to a very small extent into $\overset{+}{Ag}$, $\overset{-}{Cl}$, and $2NH_3$. T. M. L.

905. *Determining Capillarity-Constants of Dilute Salt-Solutions.* **A. Gradenwitz.** (Inaugural Dissertation, Breslau, pp. 1–71, 1902. Abstract in Phys. Zeitschr. May 1, 1902.)—Mercury is contained in a U-tube with a wide and narrow limb arranged so that the mercury can be drawn out from the narrow limb to a constant level by means of a capillary point. The mercury in the wide limb is covered with water, and on adding small quantities of a stock salt-solution the change of surface tension causes a displacement of the mercury; this is compensated by addition or removal of a weighed quantity of

mercury, and from the latter the surface tension is calculated. Values determined in this way are given for NaCl, KCl, LiCl, $NaNO_3$, KNO_3, LiNO. In all cases except LiCl the specific cohesion of the water is increased by the addition of the salt, and the increment can be expressed as the sum of a positive modulus for the kation and a negative modulus for the anion of the salt. T. M. L.

906. *Density of Dilute Solutions of Sulphates.* **C. M. Pasea.** (Elektrochem. Zeitschr. 8. pp. 215–221, Jan., 1902.)—McGregor has shown (Trans. Roy. Soc. Canada (1) 8. 19, 1890) that in dilute solutions of certain sulphates a given weight of solution occupies a smaller volume than would be occupied by the water it contains. Density determinations are given which show that sodium sulphate does not cause any such contraction, but that a contraction occurs in solutions containing less than 0·36g. $CdSO_4$, 0·28g. $MnSO_4$, or 0·5g. $FeSO_4$ per 100g. of solution ; the contractions are always small, and in the case of manganese sulphate are hardly perceptible. T. M. L.

907. *Solubility of Calcium Carbonate in Aqueous Solutions of Certain Electrolytes in Equilibrium with Atmospheric Air.* **F. K. Cameron** and **A. Seidell.** (Journ. Phys. Chem. 6. pp. 50–56, Jan., 1902.)—In presence of atmospheric air calcium carbonate does not dissolve to any appreciable extent as such, but only as bicarbonate, except in sodium sulphate solutions when the solubility is relatively very great and the solution contains normal carbonate as well as neutral bicarbonate. The solubility in salt solutions exhibits a maximum at about 50g. NaCl per litre, and is much decreased if calcium sulphate is also present. T. M. L.

908. *Molecular Surface-energy of Solutions. Molecular Weight of Sulphur.* **D. Pekár.** (Zeitschr. Phys. Chem. 39. pp. 433–452, Jan. 17, 1902. Paper read before the Hungarian Academy of Science, March 18, 1901.)—The method introduced by Eötvös for determining the complexity of liquids from their surface tension can be extended to liquid mixtures, as was found from measurements of ether with carbon disulphide, with benzene, and with diphenylamine (compare Ramsey and Aston, Proc. Roy. Soc., 1894, 56. 182). On applying this method to solutions of sulphur in CS_2 and S_2Cl_2 evidence was obtained that the sulphur molecule is probably octatomic in both solvents. The paper contains a detailed description of the method used by Eötvös for the determination of surface tension. The critical temperature of S_2Cl_2 was calculated from the surface tension to be 395°. T. M. L.

909. *Clarification of Turbid Solutions.* **G. Quincke.** (Ann. d. Physik, 7. 1. pp. 57–96, Dec., 1901.)—The clarification of turbid solutions can be brought about by non-electrolytes as well as by electrolytes ; liquids like chloroform act in this way, forming an oily layer on the surface of the particles, which gradually collect into a flocculent precipitate. This is sometimes formed on the light and sometimes on the dark side of the vessel. The silvering of glass by the chemical method is regarded as a special case of the clarification of a turbid solution, the particles separating where the vessel is illuminated. T. M. L.

910. *Liquid Sulphur Dioxide as a Solvent.* **P. Walden** and **M. Centnerszwer.** (Zeitschr. Phys. Chem. 39. pp. 513–596, Jan. 31. 1902. Abstract from the Acad. Sci. St. Pétersbourg, Bull., No. 1, June 15, 1901.)—The purest sulphur dioxide has a specific conductivity $l = 0{\cdot}9 \times 10^{-7}$ in

reciprocal Siemens ohms per centimetre cube at 0°, a value intermediate between that of water, $0{\cdot}4 \times 10^{-7}$ at 18°, and that of liquid ammonia, $1{\cdot}33 \times 10^{-7}$ at $-79{\cdot}3°$ Measurements are given of the conductivity at 0° of solutions in sulphur dioxide of nineteen salts, all of them being chlorides, bromides, iodides, or sulphocyanides; in many cases the conductivity was found to be greater than in aqueous solution at 0°. Ostwald's Law of Dilution is not applicable to solutions in sulphur dioxide, nor do the modified laws proposed by Rudolphi and van't Hoff serve to express the relationship between conductivity and dilution. In aqueous solutions the equivalent conductivity often approaches its limiting value when dilutions of about 1,000 litres per equivalent are reached, but the equivalent conductivity of solutions in sulphur dioxide is still far from its limiting value at a dilution of 2,000 litres, and it is not yet possible to determine the magnitude of the equivalent conductivity at infinite dilution. For this reason it is not possible to determine with any degree of accuracy whether Kohlrausch's law of the independent migration of the ions is applicable to these solutions. In the case of aqueous solutions the temperature coefficient of conductivity is always positive at ordinary temperatures, and usually amounts to about 2 per cent. per degree Centigrade, but Arrhenius has shown that in some cases maxima of conductivity occur at higher temperatures, the temperature coefficient becoming zero and then negative. In the case of solutions in sulphur dioxide at 0° C., the temperature coefficient is irregular and usually negative, but a maximum of conductivity is reached at a lower temperature, and the temperature coefficient then becomes positive; the conductivity-temperature curves are therefore of the type first observed by Arrhenius in the case of phosphoric and hypophosphorous acids; the temperature of maximum conductivity is highest for the solutions of highest conductivity, and in some cases is above 0°, the temperature coefficient at 0° being then positive. At the critical temperature the solutions cease to conduct. Quinoline, pyridine, α-picoline, and triphenylphosphine give conducting solutions in sulphur dioxide, although the method of ionisation is by no means obvious. Molecular weight determinations by the boiling-point method lead to perfectly normal results for solutions of non-electrolytes in sulphur dioxide; the molecular elevation of the boiling-point is $E = 15{\cdot}0$. Electrolytic solutions give results of an entirely different character to those obtained with aqueous electrolytes; evidence of electrolytic dissociation was only obtained in the case of two iodides, and even here the i-factor, which measures the "degree of dissociation," decreases towards unity with increasing dilution. The majority of electrolytes appear to be strongly associated in strong solution, but all tend towards a monomolecular state in dilute solution. Sulphur dioxide has only a moderately large dielectric constant (13·75), and, contrary to the rule of Dutoit and Aston that electrolytic solvents are highly associated, is shown by its surface tension and latent heat of evaporation to be monomolecular. T. M. L.

911. *Solubility of Dicalciumphosphate in Water.* **A. Rindell.** (Comptes Rendus, 134. pp. 112–114, Jan. 13, 1902.)—The results of a number of measurements of the solubility of dicalcium phosphate in water show that: (1) The concentration of the solution increases with the time and with the amount of the salt in contact with a given volume of water. (2) The ratio H_3PO_4 : CaO is at first 1·13 and increases with the concentration to the value 1·56. Electrical conductivity determinations confirm the author's previous statements that this salt dissolves with decomposition at the ordinary

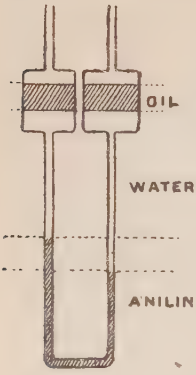
temperature, and that some times elapses before a state of equilibrium is attained. If the proportion of the phosphate employed is less than 10 grm. per litre of water, the solution becomes saturated after 252 hours. As the saturation becomes more nearly complete, the ratio H_3PO_4 : CaO of the solution increases. T. H. P.

912. *Alloys of Copper and Iron.* **J. E. Stead.** (Metallographist, 5. pp. 25–41, Jan., 1902.)—After referring to the experiments of previous investigators, the author proceeds to give the results of his own investigations, and arrives at the following conclusions: (1) That carbon when present limits the amount of copper which can be alloyed with iron, the maximum of 7·5 per cent. being the limit in gray hæmatite iron containing 3 per cent. silicon, and about 15 per cent. in steel with 1 per cent. carbon; but in most of the carbon-iron-copper alloys some of the copper exists as globules, and is only mechanically suspended in the solid metal. The amount of this mechanically suspended copper varies with the rates at which the metals are solidified, being highest when rapidly, and lowest when very slowly, cooled. The actual amount retained in solution when solid has not been fully determined. In the steel the amount does not probably exceed 7 per cent. (2) That alloys with about equal parts of copper and iron, which do not separate into two conjugate liquid layers before solidification, when remelted at a white heat on charcoal, absorb carbon, and then separate into two liquid layers, one containing about 2 per cent. carbon and 10 per cent. copper, the heavier about 10 per cent. iron and 0·08 per cent. carbon. (3) Copper in cast iron does not appear to have any influence in retaining the carbon in the combined form, or in causing a separation of graphite. (4) The micrographical study of steels containing copper leads to the conclusion that the copper retards the formation of pearlite. The same steels, differing only in copper, under like comparatively rapid cooling, when cold contain more diffused carbide when copper is present than when absent. On very slow cooling, the carbides appear to separate equally in both the cupreous and normal steels. This peculiarity explains why annealing and slow cooling have the marked softening effect referred to by Lipin and others on cupreous steels. (5) That copper in foundry iron need not be feared, as its only effect appears to be that of raising its tenacity. (6) That the somewhat conflicting statements of the authorities in our text-books appear to have been due to the fact that some of them may not have taken into consideration the effect of carbon in preventing copper alloying with iron. Pig iron will only alloy with small quantities of copper, whereas pure iron will alloy with any proportion. The article is illustrated with micro-photographs, showing the effect of etching, polishing, and heating upon different alloys. O. J. S.

913. *Thermo-chemistry of Alloys of Zinc and Aluminium.* **W. Louguinine** and **A. Schukareff.** (Archives des Sciences, 13. pp. 5–29, Jan., 1902.)—The heats of formation of the alloys were determined in a Berthelot calorimeter from the heats of solution of the alloys and of the constituent metals in dilute hydrochloric acid. The results in calories for one grm. of alloy were:— Al_5Zn, — 131·7; Al_4Zn, — 5·0; Al_3Zn, + 1·4; Al_2Zn, + 23·4; $AlZn$, + 9·1; Al_2Zn_3, + 2·3; $AlZn_2$, — 4·0; $AlZn_3$, + 15·2; so that only doubtfully in the first case, have we any evidence of the existence of a definite alloy. Heycock and Neville came to the same conclusion from an examination of the melting-points of zinc-aluminium alloys. D. H. J.

914. *Properties of Colloids.* **P. D. Zacharias.** (Zeitschr. Phys. Chem. 39. pp. 468–484, Jan. 17, 1902.)—The paper is non-experimental, and deals with the properties of colloids in general, from the point of view that the molecules of colloids may be regarded as inelastic flexible membranes, and that colloids are honeycomb masses of such membranes. D. H. J.

915. *Influence of Concentration on the Ionisation Factor of Moderately Dilute Aqueous Solutions.* **A. Smits.** (Zeitschr. Phys. Chem. 39. pp. 385–432, Jan. 17, 1902.)—A very sensitive micromonometer was obtained by utilising the small difference in density between aniline (1·028) and water (0·999) as shown in the Figure. The water was rendered feebly alkaline by boiling with soda-glass, to prevent the aniline sticking to the sides of the tube. The sensitiveness depends on the relative widths of the narrow tube containing the water-aniline meniscus and the wide tube containing the water-oil meniscus, and in the apparatus used was found by two independent methods to be in the ratio of 1 : 0·03285 as compared with a water-manometer. With the micromanometer, direct determinations of the lowering of the vapour pressure were made with aqueous solutions of salt, potassium nitrate, sulphuric acid, and cane sugar. The molecular lowering of the vapour pressure was found to increase slightly with increasing concentration in the case of cane sugar, but to decrease from an initial high value ($i = 1{\cdot}84$) in the case of potassium nitrate; in the case of salt and of sulphuric acid the molecular lowering at first decreases, then reaches a minimum at about 0·5 mols. per 1,000g. H_2O, and increases again; this minimum is not easily accounted for, but has been observed independently by Dieterici, and is in accord with observations by Loomis and Ponsot on the freezing-points of very dilute solutions. Two new forms of apparatus were devised for determining accurately the elevation of the boiling-point; NaCl and KCl gave a minimum elevation of the boiling-point at 0·3 mols. per 1,000g. H_2O, but KNO_3 gave a steadily increasing value; $Sr(NO_3)_2$ gave a minimum value, but not $NaNO_3$, $Ba(NO_3)_2$, $AgNO_3$, and $Pb(NO_3)_2$. T. M. L.

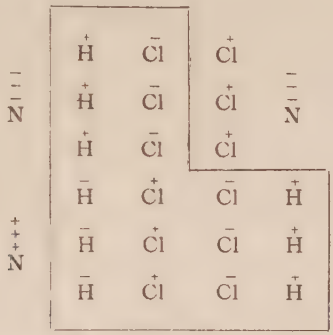


916. *Reaction between Chlorine and Ammonia.* **W. A. Noyes** and **A. C. Lyon.** (Chem. News, 85. pp. 14–15, Jan. 10, 1902.)—If dilute ammonia solution (0·5 per cent.) be allowed to act on chlorine gas, as in Hofmann's well-known lecture experiment, it is found that if excess of ammonia be avoided, so that the solution is left faintly acid, the volume of residual nitrogen approaches very closely to *one-sixth* of the chlorine. A quantitative investigation of this reaction shows that it can be expressed as follows:—

$$3NH_3 + 6Cl_2 = N_2 + NCl_3 + 9HCl$$
$$9HCl + 9NH_3 = 9NH_4Cl.$$

The nitrogen chloride was estimated by shaking out with benzene and titrating with alkaline arsenite solution. If excess of ammonia be used, the nitrogen chloride reacts with it, giving nitrogen and probably also ammonium oxychloride, whereas if insufficient ammonia be used, the ammonium chloride formed in the reaction acts on the chlorine, forming nitrogen chloride. The author's main contention is that if the reaction be conducted as described

above, then six molecules of chlorine must react *simultaneously* with three molecules of ammonia, for if the production of nitrogen chloride were due to a secondary reaction it would be difficult to explain the simple quantitative relations observable. On this groundwork the authors develope the hypothesis that all reactions involving decomposition of molecules are preceded by "ionisation," and that elementary molecules may ionise into positive and negative parts. Thus the present reaction may be formulated as follows :—



This explanation involves the further idea that in the ionisation of ammonia, the hydrogen may become either positive or negative. This view is not so improbable as it seems at first sight when one recollects that the hydrogen of ammonia may be replaced either by chlorine or sodium.

F. G. D.

917. *Internal Resistance of Galvanic Cells.* **C. H. Ayres, Jr.** (Phys. Rev. 14. pp. 17–37, Jan., 1902.)—This investigation was undertaken to determine experimentally whether the internal resistance of a cell is a function of the current. The method adopted was a modification of that due to Kohlrausch, one of the resistance arms of the bridge being made up of a fixed capacity in series with a variable resistance, and the other arm of a fixed capacity in series with the cell. The remaining arms consist of a slide wire. If a, b are the sections of the wire, then for equilibrium we have $r_1/r_2 = a/b = c_2/c_1$. The method of operation is to move the slider until a minimum is found, then vary r_2 (r_1 being supposed fixed) so as to improve the minimum ; then move the slider again, and so on. The value of r_2 was found by measurement on a separate Wheatstone bridge. The cell is either on open circuit or shunted with a known resistance as desired. Any capacity effect due to polarisation unites itself with the capacity already in circuit, and thus an error of that kind is avoided. This method determines both capacity and resistance, but the figures given only refer to the latter. Both paper and mica condensers were used, the latter having a capacity of 30 mf. Measurements on known resistances showed that the method was accurate to $\frac{1}{25}$th per cent. Upon testing Daniell Leclanché and Dry cells the author found the resistance was independent of the current.

The experimental part of the paper is followed by a theoretical part which shows how the accuracy depends upon the inductance, capacity, and resistance, and upon the frequency of the current. W. R. C.

918. *Tests of Dry Cells.* **C. F. Burgess.** (Elect. World and Engineer 39. pp. 156–157, Jan. 25, 1902.)—The author gives tests by A. A. Radtke on

number of dry cells [names not given]. The cells were submitted to both steady and intermittent tests, the results varying considerably. A rise in temperature of 70° C. increased the e.m.f. only about 0·1 volt. W. R. C.

919. *Jahn's Measurements of the E.M.F. of Concentration Cells.* **R. A. Lehfeldt.** (Zeitschr. Phys. Chem. 37. pp. 308–314, May 31, 1901.)—Employing Nernst's formula for the e.m.f. of a concentration cell, Jahn calculated from his experimental results values for the degree of ionisation of strong electrolytes which agreed with the Ostwald-Planck "Dilution-law." According to the author this conclusion of Jahn's is invalid, inasmuch as the argument involves a *petitio principii*. Let E = e.m.f. of concentration cell; C = total concentration of electrolyte; r = degree of ionisation; i = van't Hoff's factor; x = transvection-coefficient of the kation. Thermodynamical reasoning leads to an equation expressing E in terms of C, i, and x, which may be written $E = f_0(C, i, x)$. If Boyle's law holds for the solution, *i.e.*, if $r = i - 1$ (binary electrolytes only being considered), this becomes $E = f_1(C, r, x)$, while Nernst's formula may be written $E = f_2(rC, x)$, and the Ostwald-Planck Mass Action law $r = f_3(C)$. Calling the last three equations (1), (2), and (3) respectively, and granting the validity of Boyle's law as applied to the dilute solutions concerned, equation (1) must be true. Now equation (2) follows from (1) only if (3) be true, as was first shown by Krüger [see Abstract No. 1550 (1901)]. Hence if (3) does not hold, neither will (2). Yet a series of *fictitious* values of r calculated on the *assumption* that (3) did hold good would satisfy (2), and conversely. This is the error made by Jahn according to the author. The latter accordingly recalculates Jahn's results (for KCl and NaCl), employing the equation (1). The values of r so obtained are, however, uniformly higher than those calculated from the conductivities. This unexpected result is discussed by the author, and various possibilities considered, the final result being that the whole question must for the time being be left undecided. [See also Abstract No. 1145 (1901).] F. G. D.

920. *Gas Cell Measurements.* **V. Czepinski.** (Zeitschr. Anorg. Chem. 30. 1. pp. 1–18, 1902.)—The author finds for the e.m.f. of the hydrogen-oxygen cell values as high as those derived from Bose's extensive researches. He next goes on to record his investigations on concentration cells, drawing the following conclusions from the results of experiments: Methyl hydride is a gas electrically entirely indifferent, being able to affect the potential of other gases possessing electromotive activity only by diluting them. Hydrogen partial pressure electrodes will very quickly reach a state of equilibrium. The smaller the partial pressure of the hydrogen surrounding the electrode the more slowly is this equilibrium arrived at. Diminution of kinetic energy and corresponding increase of potential energy are mainly a consequence of the depolarising effect of oxygen and of diffusion phenomena. The slightest traces of oxygen will exhibit a noticeable influence, the more so the more dilute the gas exposed to the effect of oxygen. A. G.

921. *Secondary Reactions in Electrolysis.* **J. W. Richards.** (Frank. Inst., Journ. 152. pp. 201–222; Discussion, pp. 222–224, Sept., 1901.)—The author considers secondary reactions, which he defines as those reactions whereby substances other than ions come into existence at the electrodes. The energy rendered latent by electrolysis includes the energy necessary for secondary as well as primary reactions, and the former generally assists the current. After

considering the effect of temperature the author gives a classification of secondary reactions, and examples showing the effect of secondary reactions upon the voltage necessary for electrolytic decomposition. W. R. C.

922. *Influence of Diaphragms on the Transport-Numbers of the Ions.* **W. Hittorf.** (Archives Néerlandaises, 6. pp. 671–688, 1901.)—Many determinations of transport-numbers made forty years ago with the help of diaphragms differ substantially from more recent determinations by Jahn [see Abstract No. 1967 (1901)] and others without using diaphragms. The diaphragms were introduced in order to prevent the wandering from the cadmium anode of traces of cadmium solution which tend to move upwards through the liquid instead of sinking down to the bottom of the vessel. The earlier conclusion that a porcelain diaphragm does not affect the transport-number is now confirmed, and silk gauze can also be suitably used for the same purpose. But it is now shown that when an animal membrane is employed abnormal values frequently occur; in the case of KCl, NaCl, and NH_4Cl the only effect of the membrane is that a small amount of the solution is carried through it with the current, but without any change of concentration and without affecting the transport-number; in the case of $MgCl_2$, $CaCl_2$, $BaCl_2$, and especially $CdCl_2$, the effect of the passage of the current through the membrane is to cause the solution to pass through it *in the opposite direction*, and at the same time the liquid passing through the membrane is concentrated, in one case at least, to six times the strength of the bulk of the solution; in such cases when an animal membrane is used as a boundary for determining the migration of the ions the values obtained for the transport-numbers are altogether incorrect. By means of a device of Töpler (Pogg. Ann. 127. 556), these phenomena can be rendered visible to the eye, and, with a current passing upwards through a horizontal membrane, streaks of heavy liquid are seen falling down from the membrane, whilst the exhausted liquid from the upper side of the membrane rises to the surface, in the case of cadmium chloride and other salts of the group; in those cases where the membrane does not affect the transport-numbers no such streaks are seen. By this optical method LiCl and the iodides, nitrates, and acetates of the alkalies are shown to behave normally, whilst $TlNO_3$, $AgNO_3$, HCl, HNO_3, and even $CuSO_4$ (which gives practically a normal transport-number) are classed with $CdCl_2$. T. M. L.

923. *Potential Difference in Gas Flames and Solid Electrolytes.* **R. v. Hasslinger.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 696–705, May and June, 1901. From the Privat laboratorium des Verfassers in Prag-Smichov.) —The author investigates the potential difference that arises between two metal leaves suspended in a flame containing various solid electrolytes. The results are different from those for aqueous solutions or for ionised air. The leaves suspended in the flame are capable of being moved to different parts, and it is found that only in the symmetrical position do leaves, even of the same metal, show no potential difference. The leaves are connected by a reversing key to a Kelvin electrometer. A Teclu burner was used, and into it the solution of the salt to be investigated was sprayed. Both the sprayer and the burner were regulated by manometers. Results are given for leaves of iron, nickel, and platinum and for a variety of salts. The effect of variation of temperature for an iron platinum pair of leaves is also investigated, the electrolytes in this case being in a molten condition. The temperature is measured by a platinum palladium thermo element. Iron and platinum leaves in melted lithium chloride give volts 0·68, 1·07, 0·88, 0·77 for

temperatures 350°, 800°, 1,000°, 1,100° respectively. This turning-point in the e.m.f. for rising temperatures led to the idea that at higher temperatures the e.m.f. would pass through zero, and then change sign. This being investigated for magnesium oxide and calcium oxide, proved correct, and an illustrative curve for the latter is given, showing the zero point at nearly 1,000°. The lithium chloride vapour of the first experiments was then investigated for the same effect. For the high range (1,000° to 1,500°) the flame was employed, and for the lower temperatures (500°–800°) the salt was vaporised in a platinum tube. A similar reversal of e.m.f. was found.

J. W. P.

924. *Theory of Electrolytic Preparation of Copper.* **F. Egli.** (Zeitschr. Anorg. Chem. 30. 1. pp. 18–86, 1902.)—The author gives first a very full account of previous endeavours to prepare copper by an electrolytic process. From his own extensive researches on the matter the following are the main conclusions arrived at: Cu_2S being the anode in a sulphuric acid solution, copper will dissolve as copper ion, while the sulphur precipitated will give rise to passage resistances. With respect to Bernfeld's results, that with high current densities oxidation will take place, the author points out that this was not observed at densities in commercial use. Cu_2S being the anode in a hydrochloric acid solution, copper will partly dissolve as copper ion, though there may be an excess of chlorine separated. The dependence of the ratio of cuprous- and cupric-ions on density of current and acid has not yet been determined, but the author finds that under certain definite conditions cuprous chloride is formed. Sulphur will be oxidised to $H_2(O)_4$ by nascent Cl. Cu_2S being the anode in an alkaline solution, Bernfeld's researches have shown that the metal will be converted into its hydroxide, the sulphur passing through all degrees of oxidation to sulphuric acid. Cu_2S being the kathode in an acid solution, according to Bernfeld's results, sulphuretted hydrogen will be produced at the kathode, the metal remaining at the electrode, while in an alkaline solution sulphur will dissolve as ion, the metal forming a muddy mass. The author confirms these results. After these preliminary studies, the author more particularly tests the precipitation of copper from cupric chloride solutions. As rapid circulation of the electrolyte greatly diminishes the amount obtained, it should be only just sufficient to maintain uniformity in the electrolyte. The presence of hydrochloric acid, while assuring a greater purity of copper, will considerably diminish the efficiency of the process. The addition of NaCl is favourable to purity, as it tends to prevent the formation of cuprous chloride, with only a slightly decreased efficiency. A large percentage of cupric chloride is unfavourable either to efficiency or purity, as it increases the formation of cuprous chloride; but the percentage should not be less than about 0·05 molecule per litre, as the metal would then separate in a spongy state. Raising the temperature enables the current density to be increased, giving higher efficiency, the solubility of copper in the electrolyte not being sensibly affected thereby, as long as Faraday's law is satisfied. From an electrolyte of the composition: 0·1 molecule $CuCl_2$, 0·1 molecule HCl and 0·4 molecule NaCl, a precipitate containing 99·90–99·98 per cent. of copper has been obtained.

A. G.

925. *Precipitation of Colloids by Electrolysis.* **W. R. Whitney** and **J. E. Ober.** (Zeitschr. Phys. Chem. 39. pp. 630–634, Jan. 31, 1902.)—Starting from the work of Linder and Picton on the precipitation of colloidal

solutions of arsenious sulphide by solutions of barium chloride, the authors find that the precipitated sulphide of arsenic contains a definite percentage of barium in the case of dilute solutions of precipitant and sulphide solution; this percentage is independent of the amount of barium chloride used as precipitant or its concentration. When solutions of calcium chloride, strontium chloride, or potassium chloride are used in place of the barium chloride, similar results are obtained. Moreover, the amounts of calcium, strontium, or potassium in the precipitated sulphide are chemically equivalent. D. H. J.

926. *Polarisation-Capacity and Dissipation of Energy of Voltameters carrying Alternating Currents.* **A. Franchetti.** (N. Cimento, 2. pp. 312–318, Nov.–Dec. 1901.)—The author gives the results of measurements of these magnitudes, made by the three ampere-meter method, for voltameters with (1) electrodes of lead or iron with sodium carbonate solution as electrolyte: and (2) electrodes of nickel, the electrolyte being a solution of sodium carbonate, or nickel sulphate or potassium or sodium hydroxide. The voltameters with lead electrodes and containing saturated sodium carbonate solution exhibit at temperatures of 10–15° a minimum of capacity for a certain value of the effective potential difference applied to the poles, this varying, according to the formation of the voltameter, from 0·89 to 1·07 volts. Under such conditions, and considering the voltameter as constituting two condensers in cascade, the capacity per sq. cm. of electrode varies from 530 to 290 microfarads, and the lead of the current with reference to the potential difference at the poles from 48° to 58°, whilst the increase of the resistance (energy dissipated divided by the square of the current intensity) over the resistance of the electrolyte attains finally to three times the value of the latter. With iron electrodes, however, the resistance of the voltameter is but slightly greater than that of the electrolyte, and is almost independent of the intensity of the current; the capacity varies from 980 to 2,200 microfarads per sq. cm. Voltameters with nickel electrodes, and electrolytes of alkaline carbonates or hydroxides, show similar behaviour. For nickel electrodes and an electrolyte of potassium hydroxide curves are given of the variable quantities for different frequencies. It is found that the impedance increases only to a very slight extent with the frequency, and that the mean capacity during a period is inversely proportional to the frequency. The increase of resistance of a voltameter over that of its electrolyte has been attributed by Wien to spontaneous depolarisation, but, in the light of his present results, the author considers the greater dissipation of energy as due partly to an increase of resistance and partly to polarisation loss. T. H. P.

927. *Electric-resistance Magnesia Crucible-furnace for Laboratory Use.* **H. M. Howe.** (West. Electn. 30. p. 28, Jan. 11, 1902. Paper read before the American Institute of Mining Engineers at its Mexican meeting in Nov., 1901.)—This furnace is employed by the author for the determination of the cooling curves of steel and the determination of melting-points. It was originally designed by him for use in calibrating thermo-electric couples by means of the melting-point of copper. The furnace itself consists of two semi-cylinders of magnesia, with a cover and cone-shaped stopper of the same material, the stopper being perforated to admit the leads of a thermo-electric couple. The interior of the furnace is designed with a spiral groove, fitted with a coil of platinum wire, through which a current of any desired strength is passed, and by means of which the crucible is heated. In the

author's opinion the unsuccessful attempts with furnaces of this class may be attributed to the use of siliceous materials for the furnace walls, the silica, upon electrolysis, decomposing, and the resultant silicon alloying with the platinum. The employment of magnesium, however, overcomes this difficulty. A detailed sketch of the furnace is given. O. J. S.

928. *Current Efficiencies Obtained in the Electrolytic Production of Alkaline Hypochlorites and Chlorates.* **F. Foerster** and **E. Müller.** (Zeitschr. Elektrochem. 8. pp. 8–17, Jan. 2, 1902. From the Elektrochem. Laboratorium, d. Köngl. Hochschule at Dresden.)—These investigations are a continuation of the previous work by Foerster [see Abstract No. 1946 (1899)]. The authors state that they have obtained practically theoretical yields in the case of chlorate production, and have also defined the yields in the case of hypochlorites. The chief causes of bad yields are kathodic reduction of the hypochlorites, and the evolution of gaseous oxygen, as already pointed out by former investigators. Chromates added to the electrolyte prevent this kathodic reduction, as found by Imhoff, and also E. Müller, inasmuch as they form a diaphragm round the kathode, and also prevent the disintegration of the latter, no matter whether they consist of metal or carbon. (1) Reduction of evolution of oxygen in the production of hypochlorites. The employment of chromates admits of the use of much greater concentration, and thus ensures a higher yield. The following table shows the results so far obtained by various investigators :—

Investigator.	Temperature.	Current Density at Anode.	Grs. per Litre.	E.M.F.	Yields.		Current Efficiency.
					Grs. of Hypochlorite per litre.	Grs. of Available Chlorine per litre.	
Brochet ...	15·5	0·045	200grm. KCl	4·2	5·4	23·5	84·0
E. Müller	8–12	0·075	300grm. NaCl	5·4	4·36	19·3	92·0
E. Müller	8–12	0·075	300grm. NaCl	5·4	5·88	26·0	80·0
Foerster ...	13	0·17	280grm. NaCl	5·0	6·8	30·1	82·0
Haber und Grinberg...	20–24	1·0	200grm. KCl	...	5·16	22·84	32·4
Haber und Grinberg...	18–30	2 0	200grm. KCl	...	3·15	13·96	80·0

From this table it may be seen that in order to obtain high hypochlorite concentrations high current density had to be used ; on the other hand, by the use of chromates there is no limitation in this direction. Solutions of alkaline chlorides, to which chromates have been added, and electrolysed at low temperatures between electrodes covered with platinum black, are the best conditions under which hypochlorites can be produced. Tabulated results, showing a current efficiency in the neighbourhood of 95 per cent., illustrate this contention. 1 grm. of hypochlorite-oxygen required from 8·8 to 16·6 watt-hours. Solutions containing as much as 38·5 grm. available chlorine per litre were obtained. The best technical results hitherto obtained in the production of hypochlorites were 13 grm. of chlorine per litre with an expenditure of 25·5 to 40·9 watt-hours per grm. of hypochlorite-oxygen, thus showing what a great progress the authors have made in this direction. The chromates contained in the authors' solutions can be easily removed by careful neutralisation with barium chloride. The covering of the electrodes with platinum black is

done electrolytically from solutions of platinum hydrogen chloride and lead acetate. (2) Reduction of evolution of anodic oxygen in the case of chlorate production. The authors state that in submitting neutral alkaline chlorides to electrolysis it is possible to obtain a 90 per cent. current efficiency with the use of smooth platinum anodes if, before the maximum concentration of hypochlorite is obtained, the solution is partly or exactly neutralised by acid. Particulars of experiments on these lines, as well as tables, are given. Practically theoretical yields were obtained when using anodes covered with platinum black, chromates as depolarisers, and with the judicious use of hydrochloric acid. O. J. S.

929. *Darling's Method of Electrolytic Decomposition of Fused Nitrates.* (Frank. Inst., Journ. 153. pp. 61–63, Jan., 1902.)—A committee appointed by the Institute to investigate the Darling process for obtaining metals and nitric acid from fused nitrates have reported as follows : The process is protected by American patents—517001 of 1894, 590826 of 1897, and 641276 and 641438 of 1900. The last-named patent is the most important, and describes a device for using the current to protect the diaphragm from the action of the sodium, which is otherwise liberated at its surface. The experimental plant, which was witnessed in operation, worked satisfactorily, but the power required to work it is high, owing to the resistance offered by the diaphragms. The process is, however, likely to be of value where cheap power is available. A material suitable for use in fused nitrates as diaphragm has been discovered, and the difficulties attendant upon the practical use of such diaphragms have been overcome by an ingenious device. A John Scott Premium and Medal have been awarded to the inventor. J. B. C. K.

930. *Corbin Process and Cell for the Electrolytic Production of Chlorates.* **J. B. C. Kershaw.** (Elect. Rev. 50. pp. 83–84. Jan. 17, 1902.)—This article deals with the commercial development of the above process, which is carried on at the works of Messrs. Corbin & Co., at Chedde, in Savoy, where it has been in operation since 1896. The current efficiencies of the various electrolytic cells for chlorate production have varied in the early days of the manufacture between 35 and 52 per cent., but recent laboratory investigations have proved that much higher efficiencies than these can be obtained if the reducing action of the hydrogen liberated at the kathode be suppressed. The addition of alkaline carbonates, calcium chloride, and potassium chromate to the electrolyte have been recommended for this purpose, and although exact information is not available, it is probable that one or other of these additions to the electrolyte is now adopted at the Chedde Electrolyte Chlorate Works, for in a recent letter to the author P. Corbin states that a current efficiency of 85 per cent. is attained in the process, and that it is hoped ultimately to attain one of 90 per cent. The consumption of chlorates since 1899 has rapidly grown, and the chlorate and perchlorates produced at Chedde are largely used in the manufacture of a new explosive called "Cheddite." A description of the plant is given, besides sketches showing construction of cell. [See also Abstracts Nos. 1760 (1899) and 928 (1902).] O. J. S.

931. *Fusion of Quartz.* **R. S. Hutton.** (Manchester Lit. and Phil. Soc., Mem. 46. 2. pp. 1–5, 1901–1902.)—This paper gives some useful references to the literature of the fusion of quartz. The author repeated Moissan's experiment on the volatilisation of flint-stones in an electric furnace ; he observed

that the residual unvolatilised silica was very glassy, and in parts quite transparent. Further experiment showed that, provided a small current of air is allowed to pass through the furnace, no reduction of the solid or liquid silica takes place; consequently the arc can be used as a source of heat for fusing silica without fear of spoiling the results by reduction. For building up small rods, grooves are cut in a plate of graphitic carbon prepared in the electric furnace, and small pieces of quartz are placed in these grooves; they are melted together gradually from one end to the other of the grooves by sliding the plate under the arc-flame. Shapes of various kinds can be formed in a similar manner. The black stains caused by reduction can be made to disappear by bringing the heated mass for a short time away from the middle of the flame. By cutting passages in the sides of a Moissan furnace, so that a carbon support charged with quartz can be passed under and at right-angles to it, thick-walled tubes of quartz with a core about one-eighth of an inch were prepared. A 50-volt arc was used, at 300 amperes. Pure white sand fused in a similar manner gives a much more opaque mass when fused, but plastic quartz can take up a certain amount of sand without impairing the transparency. The author suggests that probably a small sand-blast, blowing sand or fine quartz, could be used for thickening bulbs and tubes of quartz fused by this method. R. A.

REFERENCES.

932. *Electrode Potentials.* **F. Haber.** (Zeitschr. Elektrochem. 7. pp. 1043–1053, Dec. 5, 1901. From the Chemisch-technischen Institut der Technischen Hochschule, Karlsruhe.)—This paper does not admit of a detailed abstract. It contains nothing essentially new, but gives a very useful discussion and summary of oxidation and reduction potentials. The "electrodes" dealt with include the following: Zinc electrode; hydrogen electrode; iodine electrode; ferrous-ferric electrode; permanganate electrode; oxygen electrode; ferrocyanide-ferricyanide electrode. F. G. D.

933. *Electrolytic Production of Alkalis.* **H. Seibert.** (Elektrochem. Zeitschr. 8. pp. 167–173, Nov., 1901.)—An account of electrolytic methods for the manufacture of alkalis, with figures of the apparatus, and calculations as to the cost of production. W. C. B.

934. *Electrochemical and Electrometallurgical Industries in* 1901. **J. B. C. Kershaw.** (Electrician, 48. pp. 421–423, Jan. 3, and pp. 462–464, Jan. 10, 1902.)

935. *Electrochemical and Electrometallurgical Industry.* **J. B. C. Kershaw.** (Elect. Rev. N.Y. 39. pp. 446–447, Oct. 12; 511–513, Oct. 26; 628–630, Nov. 23; 719–721, Dec. 14, 1901; 40. pp. 39–41, Jan. 11, 1902.)—This is a series of papers describing recent progress in the United States and Europe. G. W. DE T.

936. *Metallic Carbides.* **H. Moissan.** (International Chemical Congress at Paris, Reports, pp. 52–68, 1901.)—A summary of work done on the preparation of carbides, mainly with the help of the electric furnace, and a description of their properties. It is suggested that petroleum is formed by the decomposition of carbides. T. M. L.

937. *Recent Discoveries in Cryoscopy and Tonometry.* **Raoult.** (International Chemical Congress at Paris, Reports, pp. 28–32, 1901.)—A summary, by the discoverer of the method, of the results obtained by determining molecular weights from the elevation of the boiling-points, depression of the freezing-point, and lowering of the vapour tension of solutions. T. M. L.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

938. *Superheated Steam Engine.* **H. G. Chatain.** (Horseless Age, 9. pp. 68–69, Jan. 15, 1902.)—The author points out the difficulties met with when ordinary double-acting slide or piston-valve engines are used in connection with flash boilers supplying superheated steam, and discusses the advantages of single-acting engines in which poppet valves are used for admission of the steam, and ports in the cylinder wall for exhaust, or poppet valves for both operations. The former valve arrangement is preferred from its great simplicity. The cylinders are conveniently lubricated by the splash from an oil-bath crank chamber. C. R. D'E.

939. *Steam Engines Driving Alternators in Parallel.* **M. Leblanc.** (Soc. Int. Élect., Bull. 1. pp. 497–502, Nov., 1901.)—Designers of engines intended to drive alternators have in general paid too much attention to the "coefficient of irregularity" of their engines, and have tried to make their governors as isochronous as possible; the phenomenon of electro-mechanical resonance developed when alternators are working in parallel or when an alternator is driving one or more synchronous motors, has been generally ignored. The load of an alternator coupled in parallel is not a function of the speed merely, as it is when it is running separately, but depends on the amount of its lead or lag with respect to the others. A mechanical analogue is afforded by a number of steam engines, each belted to a separate pulley on a single shaft; the driving pulleys on the engines are rigidly keyed each to its own shaft, but the pulleys on the transmission shaft are each connected to it by an elastic coupling. The load on the shaft is a function of its speed of rotation merely. Thus any engine is free to run quicker or slower than the others within the limits of its elastic coupling, and it can assume oscillatory movements with respect to the others. An engine can cease to do work, and can be pulled round by the others, if its governor is improperly adjusted; this may result in serious accidents, such as the drawing up into the cylinder of water from the condenser. As regards the influence of the elastic couplings (a subject which has been studied since 1894 by Picou, Guillaume, Arnoux, and Desroziers) it is shown mathematically that the angular motion of a pulley on the shaft with which it is thus connected can be looked upon as the superposition of a uniform motion Ω_m, which is the mean velocity of the shaft, and of a pendulum motion of a frequency proportional to Ω_m, of which the amplitude involves other factors besides the moment of inertia of the pulley; and further, under certain conditions other pendulum movements of different frequencies would be developed. To get rid of these it is not sufficient that the engine should have a small coefficient of irregularity; it is also necessary to take into consideration the harmonic terms of the expression for the torque, and to neutralise all those of a certain frequency. The oscillations, if of short period, can be damped out by purely electrical means; but this is not the case if they have a period of, say, several seconds, as they might have if caused by hunting of the governor of the engine. B. P. S.

940. *Experimental Determination of Cyclic Variation in Angular Speed of Steam Engines.* **L. E. F. David.** (Soc. Int. Élect., Bull. 1. pp. 503–519, Nov., 1901.)—The apparatus and experiments described in the paper were arranged by Weyher and Richemond, the first series of results being given to the society in July last, since when fresh experiments have been made in collaboration with Leblanc and Lorin. The paper begins with a theoretical discussion of the definition and calculation of the "coefficient of regularity" k, and it is explained by the aid of diagrams how to determine this coefficient, for a flywheel of given moment of inertia, from the piston pressure, the effort exerted on the connecting rod, and the effort tangential to the circumference described by the crank. From these data and the curve of resisting moments (a straight line for the more usual case of constant resistance) the excess of motive work over resisting work, or *vice versâ*, may be determined for every part of the stroke, and hence the acceleration (positive or negative) of the flywheel at any instant can be deduced.

Two definitions of k are given [see Abstract No 568 (1902)], the author giving the preference to $(V_{max} - V_{min})/V_{mean}$. The angle of maximum displacement, θ, is then discussed, and it is shown how the angle may be theoretically deduced. The apparatus designed for the purpose of determining it experimentally is described. At the end of the engine shaft a disc is fixed carrying on its face a sheet of smoked paper. A tuning-fork, with a point fixed upon one of its prongs, traces a sinuous curve on the revolving disc, the mean path of the tracing-point with respect to the axis of the plate being of course circular. This circle is traced by the point with the machine at rest, and another circle is also traced, outside the diagram, and concentric with it. On the outside this latter circle is divided externally into the same number of equal parts as the number of waves traced by the pointer in one revolution, and on the inside of the same circle as many unequal parts are set off by radial lines through the intersection of the wave and the median line. Thus the outer circle shows externally the uniform movement of the ideal crank, and, internally, the varying movement of the real crank. The maximum displacement of the internal and external divisions gives the measure of the angle θ. The method lays no claim to any great precision, but is sufficient to show whether the calculated value of θ is of the same order of magnitude as the true value. In the apparatus actually used it is necessary to provide against difficulties due to end play in the shaft or to the disc not being quite perpendicular to the axis of the shaft. This is done by means of a rigid arm attached to the base of the tuning-fork, which allows the latter to turn on its support and to approach or recede from the plate. A small roller fixed on the end of the arm preserves the distance between the fork and the disc constant. A large number of plates accompanies the paper, some showing actual diagrams taken with the instrument and others being curves of steam pressure, crank effort, resistance, &c., of various engines, with the resultant speed curve of the flywheel, from which the coefficient k is obtained by direct measurement. A table is also given with data of the engines experimented on at various times, and the value of θ found as the results of the tests, a parallel column giving calculated values of θ. The agreement between the observed and calculated values is better at light than full loads.

B. P. S.

941. *Optical Method of Determining the Law of Periodic Variation in Rotary Motion.* **A. Cornu.** (Soc. Int. Élect., Bull. 1. pp. 519–529, Nov., 1901.)—The author employs a horizontal circular plate, capable of rotation about a vertical

axis through its centre and carrying a cylindrical ring concentric with the axis, pierced with a series of perfectly equidistant holes. A horizontal beam of light of parallel rays is made to traverse the ring from side to side and to project its shadow upon a screen. When the ring is set rotating, a ray of light passing through a hole in the side of the ring nearest to the source of light is stopped by the material of the ring, except when a hole in the side of the ring near the screen is in line with it, and the poles being equidistant and moving, on each side of the ring, with equal velocity and in opposite directions, the result is that a line of motionless patches of light is seen on the screen. If now another ring is used, in which the holes, instead of being equidistant, are spaced so as to subtend equal angles about a point in the plate at a distance a from the centre, the author shows that the result is precisely the same as if the holes in the ring were equally spaced, but the ring itself moving, as regards the half of it near the source of light, with a velocity varying periodically according to the sine law, the half of the ring near the screen still moving uniformly. In fact, each hole in the ring, instead of occupying the position defined by the equation $x_m = x_0 + m\mathrm{C}/\mathrm{N}$ (where C = circumference of the ring, N = total number of holes, m the number, counting from zero, of the hole in question, and x_0 the distance from the origin of the hole numbered 0) now has its position defined by $x_m = x_0 + m\mathrm{C}/\mathrm{N} + \sin 2\pi(m_1 - m_0)/\mathrm{N}$, where m_0 is the number counting from zero of the hole which defines the diameter passing through the two axes. Consequently, two holes situated at opposite ends of a diameter (for which $m - m' = \mathrm{N}/2$) undergo changes of position which are equal and of opposite signs ; the result being that a ray of light passing through these two holes at the most favourable position will appear to oscillate from $+a$ to $-a$ at every revolution of the ring. The author goes on to show that if R be the radius of the ring, a/R represents the angle of eccentricity in circular measure, when a is small, and this is the same thing that engineers call the angle of displacement. In order to measure the travel of the spots of light, a modification of the method above described is used. By means of two right-angled prisms a ray of light is reflected from the inside of the ring through the holes pierced in its circumference, and then through a series of equidistant holes in the edge of a uniformly revolving disc upon the sensitive plate of a camera, to which is given a regular rocking movement about an axis parallel to the series of images. The negative, when fixed, shows a series of points of light disposed in a straight line, when the image to the eye is stationary, and in the form of a sinoidal curve when the image oscillates. Measurements made on the photographic plate give the eccentricity for each of the holes in the ring ; if one of these is stopped up the phase of the periodic curve can be at once determined. It is not necessary that the rotating disc should be moving with absolutely the same velocity as the ring ; a slight uniform acceleration in either sense has merely the effect of making the photographic trace slightly oblique in direction ; the ordinate of each point is then measured as if referred to oblique axes. In the industrial application of this method, as, for example, in analysing the velocity of a flywheel, round-headed steel studs might be arranged circumferentially on one of its faces, and illuminated by an arc lamp. A lens of suitable focus would project the circle of luminous points on to the revolving disc, and the photographic trace would be made as described. It is obvious that whatever the law of speed variation, it would be faithfully recorded ; it has only been assumed to be the sine law for the sake of simplicity. As to the accuracy obtainable, the angle of displacement a/R being inversely proportional to the radius of the circle on which the luminous points are disposed, and the quantity a being of the order of two or three millimetres,

displacements of a small fraction of a degree can be easily measured in a flywheel of ordinary size. B. P. S.

942. *Cyclical Speed Variation in Steam Engines Driving Alternators.* **P. Boucherot.** (Soc. Int. Élect., Bull. 1. pp. 529–553, Nov., 1901.)—This paper is a discussion of the relation between θ, the angle of maximum displacement of the flywheel of the engine driving an alternator [see Abstract No. 568 (1902)], and 1 R, the irregularity; this quantity is defined as the ratio of the difference between the maximum and minimum angular speeds and twice the mean angular speed. The cases discussed are those of an *isolated set*, or an engine driving an alternator singly, and a *coupled set*, the engine and alternator being supposed connected in parallel on infinite mains of constant frequency. The influence of the engine governors is, for the present, left out of account. The simple case first considered is that in which the function connecting angular velocity and time is a pure sinoidal curve superposed on a straight line; it is shown that in this case $\theta = 1/n$R, where n is the number of impulses per turn corresponding to variations in the torque. Thus for a single cylinder engine $\theta = 1/2$R, or the angle of maximum displacement is one-half the irregularity. In most cases, unfortunately, the function connecting speed and time is a complicated Fourier series. In this connection the author refers to a series of 28 diagrams, which are reproduced, and which were supplied by four different engineering firms, and relate to engines of various types, with one, two, and four cylinders, and of which the sizes go up to 1,500 h.p. These diagrams, which show graphically the relation between turning moment and time, have been analysed by the author and expressed in Fourier's series; a table is given showing the values of the coefficients of the first eight terms. Some of these curves are discussed at length, and the values of θ, calculated from the irregularity by means of the Fourier's series, are compared with the values assigned by the engine builders, the results being very concordant. The author then discusses the mathematical theory in the case of "coupled" sets, and shows that, contrary to the usual belief, the angle of displacement, in the case of alternators running in parallel, is *increased* where there is damping. It is shown that the ratio σ of θ coupled (no damping) to θ isolated, can be expressed very simply as $\sigma = W/(W - W_r)$, where W is the *vis viva* of the flywheel ($= \frac{1}{2}I\Omega^2_{mean}$) and W_r the corresponding value when there is resonance. In a particular case, a table is given showing values of σ corresponding to different values of the alternator reaction: this latter quantity being measured by the ratio of the normal current to that on short-circuit.

The conclusion reached by the author is that for safe parallel running it is unwise to allow such a large angular displacement as is sometimes assumed to be safe. The effect of damping is considered, and its influence (especially near the point of resonance) in causing the increase of the flywheel action to *increase* the ratio σ is deduced. The latter part of this important paper is taken up with a discussion of the influence of the higher harmonics in the Fourier's series, both in the case of an alternator running on mains in which the frequency is rigidly constant, and in that of two alternators coupled together. Summing up his results, the author believes that the period of oscillation of an alternator can be calculated with an exactitude which is sufficient for practical purposes. B. P. S.

943. *Calculation and Measurement of the Angle of Displacement of a Rotating Flywheel.* (Soc. Int. Élect., Bull. 1. pp. 584–600, Dec., 1901.)—This is a report

of the discussion on the last four papers. **Rateau** objected that the theories on which the calculation of θ had been based, assumed the resisting couple to be constant; in the case of an alternator this is not so; however, the error is negligible except in the case of a small number of poles. With alternators in parallel, it is not the angle θ of one machine which should be considered, but the difference $\theta - \theta$ between the angular displacements of the two coupled machines. In the case of alternators with different numbers of poles, when these numbers are prime to each other pendular movements of long period may be set up. The method described by Cornu is more suited to the laboratory than the workshop; for the latter a mechanical rather than an optical method is preferable. If on the shaft to be tested a carefully cut bevel wheel is fixed, and on the prolongation of the axis a similar wheel is arranged on another shaft provided with a flywheel and kept in uniform rotation (by means, for example, of an electro-motor) in the opposite direction, then the movement in either direction of a third wheel geared between the two would, provided the mean speeds of the two shafts are the same, be a measure of the angular displacement of the first shaft at any instant. To give sensitiveness, the motion of the first shaft should be geared up by a train of spur wheels. If the mean speed of the uniformly rotating shaft be different from that of the shaft under test, the third wheel will have a movement of *precession* as well as of *nutation*; it is the amplitude of the latter which gives the value of θ sought. **Cornu** defended his method against the charges of want of sensitiveness and unsuitability for workshop practice. An accuracy of the order of 2 minutes of arc can be easily reached with a flywheel 4 metres radius; and all the arrangements necessary for the stroboscopic method can easily be carried out by a good mechanic. **Boucherot** did not admit that the variation of the resisting couple in the case of a flywheel alternator would materially alter his equations, this factor being really of less importance than others which he had deliberately omitted as being negligible. In practice, flywheel alternators have a sufficient number of poles to make the resisting couple quite uniform. As for Rateau's second objection, the case of two alternators in parallel has already been treated in the Bulletin. **Dubois** suggested a modification of Rateau's method by which the electro-motor used for maintaining the uniform rotation of the shaft with the flywheel might be dispensed with, the spindle of the third wheel being attached to a spring of which the other end would be fastened to a fixed point. **David** thought that so far as his own method was concerned any attempt to magnify the angular displacement of the shaft by means of gearing would introduce great difficulties, illustrating his point by a concrete example. The precision attainable by his method he estimated as of the order of $\frac{1}{10}$th of a degree. **Hospitalier** would use the main shaft in Rateau's method to impart a uniform velocity to the second shaft, which he would drive from the former by an elastic coupling. The inertia of the flywheel keyed to the latter would give a practically uniform speed.

B. P. S.

944. *Measurement of Variations in the Angular Velocity of the Flywheel of an Otto Gas Engine by the Stroboscopic Method.* **A. Cornu.** [Soc. Int. Elect., Bull. 2. pp. 50–56, Jan., 1902.]—On the flywheel, which was about 1·8 m. in diameter, there were fixed at equal distances on a layer of mat varnish eighteen discs of tinfoil about 2·2 cm. diameter. The discs on the upper segment of the flywheel were illuminated by the light of an arc lamp projected from an optical lantern. A lens of 15 cm. focal length, at a distance of 2·1 m. from the

flywheel, projected the image upon a rotating disc, so that the illuminated segment of the flywheel coincided with a portion of the circumference of the disc, which was pierced with 36 round windows, and rotated by an electro-motor. (In another series of experiments, a larger disc was used actuated by clockwork.) By means of a brake the speed of the disc could be regulated to a nicety, so as to be equal to, or half or double, that of the flywheel. Oscillations of the image were thus produced in the plane of the disc ; these were registered photographically on a gelatino-bromide plate. To obtain the law of oscillation with time, the image was spread out proportionately to the time by a mirror rotating about a horizontal axis placed directly in front of the objective. Some of the plates thus obtained are reproduced in the paper ; they take the form of a series of curves concave to the horizontal axis, joined at the bottom by curves of small radius in the reverse direction. By the device of covering one of the tin-foil discs (that situated on the prolongation of the crank) with black paper, and thus eliminating one point on the curve, it is seen that the lowest point of the curve corresponds to the moment when the crank is vertical and upwards. This is the instant at which the explosion occurs in the cylinder. In the photographs the point of light at the apex of the curves is also seen to be missing ; this is because the explosion occurs only at alternate strokes. It was found that images of much better definition could be secured by using small bright hemispheres on the flywheel to reflect the light, instead of tin-foil discs ; when this substitution was made, very accurate measurements could be made by means of a Bianchi micrometer. A table is given showing the results of these measurements, which are taken to the $\frac{1}{100}$th part of a millimetre. The maximum displacement of the points of light from the mean position is 5·08 mm. ; the mean distance between two parallel curves is 7·79 mm., representing an angle of 20° (since there are 18 bright points on the circumference of the flywheel). Thus the maximum angle of displacement, which occurs every second stroke where the explosion takes place, is (5·08/7·73) × 20° or 13°·04. [See also Abstract No. 941 (1902).]

B. P. S.

945. *Measurement of the Variation in Angular Velocity of a Flywheel by Sartori's Stroboscopic Method.* **J. Blondin.** (Soc. Int. Élect., Bull. 2. pp. 57–65, Jan., 1902.)—This paper begins with a short discussion of the various methods—mechanical, electrical, optical—which have been employed to determine the periodic variations in speed of a flywheel, the conclusion arrived at being that the optical method is the only one which gives satisfactory results. A ray of light has no elasticity or inertia which could introduce errors into the results, and by means of photography the most rapid variations can be registered. Mechanical accessories being reduced to a minimum, experimental errors are also proportionately reduced ; and lastly, the variations in speed of the *rim* of a flywheel, and not merely of the shaft, can be measured stroboscopically, the two things being only identical when the elasticity of the arms of the wheel is negligible. In the method devised by Sartori two discs are employed, each pierced with slots cut exactly to the evolute of a circle, the curvature being in opposite directions in the two discs. If these are then placed so that their axes are in the same straight line, with a strongly illuminated screen behind them, a number of luminous points will be seen, resulting from the intersection of the two series of slots ; these points are disposed along a circumference, the radius of which depends on the relative position of the two discs. When the discs are rotated in the same direction with equal angular velocity, a circle of light is seen ; if one

disc moves more rapidly than the other, this circle expands or contracts, the increase or decrease of the radius being, owing to the shape of the slots, proportional to the angular displacement of the discs. In a trial of the method upon a 250-kw. Tosi-Ganz steam alternator at the Central Station at Trieste, one of the discs was rotated by a small electro-motor worked from secondary cells, so that the rotation was perfectly uniform; the other was driven by friction by means of a bicycle wheel clamped to the shaft of the alternator. The variations of velocity of the shaft were thus magnified in the disc in the proportion of about six to one. The alternator was running at the time of the test in parallel with another precisely similar set; the speed of the shaft was 104 and that of the disc 665 r.p.m.; a variation of 10 mm. in the radius of the luminous circle corresponded to a displacement of 0·24 degrees between the two discs, and the result of the test was to give a variation of 16 mm. radius. The maximum displacement of the alternator shaft as compared with the ideal (uniformly rotating) crank was thus found to be $\frac{1}{4} \times 1{\cdot}6 \times 0^{\circ}{\cdot}24 = 0^{\circ}{\cdot}19$. These alternators are therefore well suited for parallel running, as indeed is proved by the fact that they run in perfect synchronism with another 500-kw. set of which the engine also drives a direct-current dynamo supplying 200 kw. for tramway service. Under these conditions, however, it was found impossible with the stroboscopic discs to get perfect steadiness of the luminous circle; but with alternators driven independently, almost perfect steadiness was attained and the observations were easy. The law of variation of speed can be registered photographically by means of a revolving mirror. The limit of accuracy is stated by Sartori to be about 3 per cent., but the author thinks this a somewhat optimistic figure; in any case, however, the method is a useful one, and well adapted for the workshop as well as for the laboratory. B. P. S.

946. *Errors of the Indicator Diagram.* **L. C. Wolff.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1772–1779, Dec. 14, 1901.)—The author enumerates errors which are liable to occur in indicator diagrams, and concludes that the i.h.p. calculated from diagrams cannot be relied upon to the extent usually assumed, even for slow-speed engines, while for high-speed engines the figures obtained are grossly inaccurate. The chief sources of error increase with the speed, and are: (1) Error in the pressure indicated, according as the pressure is rising or falling, or other variation occurring in the conditions. Springs in tension, and not in pressure, are recommended. (2) Possible synchronism between the spring's natural period of vibration and the period of the force exerted on it. The steam also has a period of vibration which may assert itself. (3) Frictional resistance to the flow of steam in the indicator pipes giving rise to a lag in the indicated pressure. (4) Variation in the length of the diagram due to stretching of the string. The effect will not be the same at both ends of the diagram.

Sets of tests were made on a small ungoverned engine, with the speed varied from 100 to 1,000 r.p.m., and various indicator springs and pressures. The b.h.p. could not be measured. The engine was single cylindered. Diagrams are given and discussed. The conclusions arrived at are: (1) The isothermal coincides more closely with the actual expansion curve as the speed rises. (2) The compression curve coincides less closely with the isothermal as the speed rises. (3) The length of the diagram increases with the speed, especially on the near dead point. (4) Allowance should be made in the indicating gear for the thickness of the string (5 mm. say). (5) The i.h.p. calculated from the diagrams varies, at constant speed, with individual

indicators and springs. (6) After-admission increases with the speed. (7) The indicated admission line falls with an increase of speed; (8) so does the initial and final pressure. (9) The pressure on the dead point first rises and then falls with the speed. (10) The compression curve gradually disappears with rising speed. R. C. R.

947. *Pipe-Covering Tests.* **G. H. Barrus.** (Power, N.Y. 21. pp. 32–33, Dec., 1901.)—The object of these tests was to ascertain the efficiency of various kinds of non-conducting coverings for steam-pipes, as determined by the weight of water or condensed steam produced in the pipes. Two sections each 100 ft. long, of standard 2-in. steam-pipes were employed, one for steam of 150 lbs. pressure and one for steam of 80 lbs. pressure. In the 150 lbs. section two 10-in. pipes, each 35 ft. long, were used, in order to test the effect of difference of size. The tests were continued for from eight to nine hours each day on consecutive days, so that many of the coverings were tested day after day for a period of a month, and every one was subjected to at least three days' continuous run. Precautions were taken to start with dry steam, to measure accurately the water produced by condensation, and to observe the temperature and humidity of the air.

MINIMUM AND MAXIMUM RATES OF CONDENSATION IN LBS. PER HOUR FOR EACH OF THE COVERINGS TESTED.

Order of Merit.	2-in. Coverings, 80 lbs pressure.	Minimum.	Maximum.
1	John's Asbestocel	13·46	14·07
2	New York Air Cell	13·88	14·14
3	Carey's Moulded	14·18	15·00
4	John's Moulded	14·15	15·07
5	Gast's Ambler Air Cell	14·60	15·14
	2-in. Coverings, 150 lbs. pressure.		
1	John's Asbesto-Sponge Hair Felt, 3-ply	10·47	10·93
2	„ „ „ „ 2-ply	11·21	11·29
3	Asbestos Sponge Felted (Sectional)	11·20	11·57
4	K. and M. Magnesia (85 per cent. Magnesic Carb.)	11·64	12·20
5	Asbestos Fire Felt (Navy Brand)	13·18	14·00
	10-in. Coverings, 150 lbs. pressure.		
1	John's Asbesto-Sponge Felted	10·67	11·07
2	K. and M. Magnesia (85 per cent. Magnesic Carb.)	13·00	13·64
3	Asbestos Fire Felt (Navy Brand)	14·00	14·64
4	Watson's Imperial	15·79	15·93
	Bare pipes.		
	2 in., 80 lbs. pressure	55·75	60·30
	2 in., 150 lbs. pressure	71·78	72·20
	10 in., 150 lbs. pressure	105·9	112·00
	Temperature of air (approximate)	50°	75°

There were no appreciable currents of air in the test-room. No difference in result was obtained when steam was allowed to flow through the pipes at a velocity of 18 ft. per second from those yielded when the steam was

practically still. The accompanying table gives the order of efficiency of the coverings tested for each size and pressure and the maximum and minimum rates of condensation per hour for each. The condensation from the pipes without covering is also given for comparison. F. J. R.

948. *Forced Draught.* **W. H. Booth.** (Cassier, 21. pp. 130–139, Dec., 1901.)—The author expounds this subject from its elements, showing how ordinary chimney draught is produced, and what are its limitations and defects under such circumstances as those of an electric light or power-station, and what is the power represented by a given chimney draught. The fundamental rules governing the quantity of air required for combustion, and the velocity of gases, are dealt with and applied to show the advantages of forced draught by fans. The different systems, viz., by means of the closed stokehold, the closed ashpit, and the induced method, are shortly described, and for land installations preference is given to the latter for various reasons, whilst the others are more useful for marine work. Some figures are given to show the economy in first cost, in power, in working costs, and in upkeep resulting from fan draught, and the author sums up by declaring that "the system of artificial draught is one that, no matter how approached, presents a favourable appearance to the experienced engineer. It is cheap to instal and cheap to run, the power to work the fan being but a small part of the economy to be gained by its use. Not merely is the first cost small, but there is a further capital economy in the reduction of boilers or their substitution by feed-water heaters. And upon all there is the added convenience given by the facility of extending the plant, the freedom from the paralysing influence of the insufficient chimney, and the entire freedom from meteorological influence." F. J. R.

949. *Town Refuse Disposal in Great Britain.* **W. F. Goodrich.** (Cassier, 21. pp. 99-122, Dec., 1901.)—The author gives a historical sketch of the introduction of destructors, beginning with Fryer's in 1876, and then describes and illustrates the Fryer destructor at Cambridge, Warner's destructor at West Hartlepool, Baker's at Clerkenwell and Lambeth, Meldrum's at Nelson, Horsfall's at Fulham, Heenan's twin-cell destructor at Blackburn, Mason's refuse gasifier, and the Beaman and Deas' destructor at Colne. The importance of the matter to any locality may fairly be judged from the fact that from 15 to 20 cwts. of refuse are produced daily by each 1,000 of the population. In some cases the evaporative value of the refuse is as high as $\frac{1}{3}$th of that of coal, but the percentage of value differs with various kinds of refuse and different destructors, varying from $\frac{1}{3}$th to $\frac{1}{13}$th. Where the evaporative value is less than $\frac{1}{10}$th that of coal the destructor cannot well be reckoned as a power producer. In order to analyse the performance of different destructors, several Lancashire towns are selected in which the calorific value of the refuse may be presumed to be pretty uniform, and the results from these are given in the table on page 406.

In other Tables in this article are given full records of results of a twenty-four hours' test of the St. Domingo destructor at Liverpool, of one month's continuous work of the Meldrum destructor at Nelson and of a test of shorter duration in which the plant was forced, without sacrifice of the general efficiency, of a test of Heenan's destructor at Blackburn, and of Beaman and Deas' destructor at Canterbury. In all these cases the fuel value of the refuse for evaporation or steam raising, and the soundness of the principles on which these British destructors have been constructed, are demonstrated. F. J. R.

Town.	Evaporation per lb. of Refuse.	Average Steam Pressure.	Temperature of Feed Water.	Consumption of Refuse per Cell per 24 Hours.	I.H.P. Produced per Ton on Basis of 20 lbs. Steam per I.H.P.	Duration of Test.	No. of Cells or Grates in Use.	Rate of Combustion per sq. ft. of Grate per Hour.	Boilers in Use.
		lbs.	Deg. Fahr.					lbs.	
Oldham	0·880	128	212	1 cell = 7·96 tons	98	24 hours	10 cells	25	2 Lancs. 30′ × 8′
Ashton-under-Lyne	0·783	122	212	1 „ = 9·97 „	87	24 „	6 „	31	2 Multitubular
Bury	0·532	—	53	1 „ = 9	59·584	4 „	6 „	33·6	3 „
Rochdale	1·78	114	212	4 grates = t. 50 c. 15 q. 1 lbs. 4	199	6½ „	4 grates	54·9	1 Lanc. 30′ × 8′
Darwen	1·55	193	212	4 „ = 52 2 1 6	173·6	48 „	4 „	56	1 „ „
Nelson	1·516	118	212	4 „ = 61 0 0 0	169·792	9½ „	4 „	57	1 „ „
Nelson	1·85	120	212	4 „ = 31 0 0 0	207·2	1 month	4 „	29	1 „ „
Nelson	1·95	122	212	4 „ = 73 4 0 0	218·4	8 hours	4 „	68·5	1 „ „
Blackburn ...	1·39	90·8	212	2 „ = 25 9 1 12	155·68	12 „	2 „	48	1 „ 24′ × 7′
Fleetwood ...	1·19	135	212	1 cell = 21 11 2 2	133·28	8 „	2 cells	80·5	1 Babcock W.T.
St. Helens ...	1·54	127	212	1 „ = 27 12 0 8	172·48	7 hr. 20 min.	2 „	103	1 „ „
Warrington ...	1·14	68	104	1 „ = 23 0 0 0	127	24 hours	2 „	88·48	1 „ „
Blackburn ...	1·297	122·3	212	1 „ = 11 3 0 12	145·264	7 hr. 40 min.	4 „	34·66	2 Heenan W. T.
Liverpool ...	1·173	—	212	1 „ = 16 10 0 0	131·376	24 hours	8 „	62·16	4 Babcock W.T.

950. *Comparative Tests of Coal and Crude Oil as Fuel.* (Eng. News, 47. pp. 80-82, Jan. 30, 1902.)—This article contains an abstract of the Report by Prof. Denton, of the Stevens Institute of Technology, Hoboken, N.J., of a series of experiments with American coal and with Texas oil as fuel under a cylindrical return tubular boiler 6 ft. diameter by 18 ft. long, one of three in the boiler-room of the American Ice Company. An illustration of the arrangement of boiler furnace and oil supply is given, and also sectional details of the oil-burner used, which was on the familiar steam-jet injector lines. The oil was sprayed against a block of firebrick chequer-work in the furnace, and means were introduced for partially heating the air for combustion. The average quality and composition of the oil were as follows: Specific gravity, 0·920; flash point, 142° F.; burning-point, 181° F.; cold test — 6° F.; calorific value per lb. by oxygen calorimeter, 19,060 B.Th.U. Composition: Carbon 80·60 per cent.; hydrogen, 10·90 per cent.; sulphur, 1·63 per cent.; nitrogen, 0 per cent.; oxygen, 2·87 per cent. The coal used was a high grade of No. 1 Buckwheat (anthracite) coal, containing approximately: Moisture, 6·2 per cent.; ash, 11·6 per cent.; carbon, 77·5 per cent.; hydrogen, 2·0 per cent.; sulphur, 0·5 per cent.; oxygen and nitrogen, 2·2 per cent. The amount of ash resulting from the actual firing of the coal was from 16 to 18 per cent. of the total fuel. With cold brickwork and water in the boiler at 64° F. steam was raised to 85 lbs. pressure in 59 minutes with oil fuel, and in 1 hour 17 min. with coal. The draught was that which was due to a chimney 70 feet high by 42 in. square. The results of these tests are given in Table I., page 408.

In comparing the relative costs of oil and coal for producing power on the ordinary basis of 1 h.p. per 10 sq. ft. of heating surface and with average percentage of ash and moisture in coal, the evaporation per lb. of wet coal from and at 212° F. = 8·75 lbs.; the net evaporation per lb. of oil from and at 212° F. = 14·8. Ratio of oil to coal $\frac{14{\cdot}8}{8{\cdot}70} = 1{\cdot}69$. Number of barrels of oil equivalent to 2,240 lbs. coal = 4·12. Price of coal per long ton, no haulage or ash removal, = $3.00. Equivalent price of oil per barrel of 42 U.S. gallons, = $0.73. Table II., page 409, gives the cost of oil as compared with coal of various qualities. F. J. R.

GAS AND OIL ENGINES.

951. *Spark Control.* **A. L. Clough.** (Horseless Age, 9. p. 99. Jan. 22, 1902.)—The author points out the deficiencies in the present system of fitting a hand adjustment to the spark-timing apparatus attached to motor vehicle engines, and advocates the use of a timing apparatus controlled automatically by the engine, which would then itself determine the most advantageous point of igniting the charge for any condition of load. The throttle valve would then give the only necessary hand control for the engine. C. R. D'E.

952. *Vilain Cooling System.* (Horseless Age, 9. pp. 109-111, Jan. 22, 1902.)—This is a thermosyphon cooling system in which a coil of copper tubing mounted above the top of the engine cylinder has its ends connected to the top and bottom of the cylinder water-jacket. The tubing forms a closed circuit, no water-tank being necessary. It is calculated that if the copper tubing has a radiating surface of ten times the surface of the cylinder walls, its radiating power, when standing still, will keep the temperature of the jacket at 128° C. = 2·5 atmospheres pressure. A safety valve is fitted. There is no evaporation, so the water lasts indefinitely. About 1 gallon of water is carried. C. R. D'E.

TABLE I.

RÉSUMÉ OF TESTS.

Dimensions of Boiler: 6 ft. diam., 18 ft. long; 100 Tubes, 2½ ins. in diam.; Grate Surface, 45·5 sq. ft.	Beaumont Crude Oil.					No. 1 Buckwheat Coal.	
	Nov. 27.	Night of Nov. 27–28.	Nov. 28.	Night of Nov. 28–29.	Nov. 29.	Dec. 12.	Dec. 13.
Duration, hours	3·5	8	11	13	11	12	12
Horse-power	146·9	112·7	189·7	138·0	220·1	92·6	119·1
Steam pressure (gauge), lbs.	87	86	86	86	86·5	84·5	86·5
Feed temperature, deg. F.	69	90	70	90	74	68	72
Chimney temperature, deg. F.	374	360	398	370	425	389	396
Quality of steam	Dry	Dry	Dry	Dry	Dry	Dry	Dry
Moisture in coal	...	...	...	...	...	6·2%	6·2%
Per cent. of ash	...	...	...	...	...	16·2%	18·0%
Times fire was cleaned	...	...	...	...	...	Once	Twice
Coal per hour per sq. ft. of grate, lbs.	...	...	...	...	...	7·66	10·10
Coal per sq. ft. of heating surface, lbs.	...	...	...	...	...	0·182	0·247
Oil per hour per sq. ft. of heating surface, lbs.	0·181	0·135	0·226	0·163	0·263	...	...
Dry steam per hour [1] per sq. ft. heating surface, lbs.	2·73	2·09	3·52	2·56	4·08	1·72	2·21
Heating surface per h.p. sq. ft.	12·6	16·5	9·8	13·5	8·45	20·1	15·6
Total dry steam per lb. of fuel as fired,[1] lbs.	15·29	15·53	15·55	15·71	15·49	9·17	8·94
Per cent. of steam used by burner [2]	3·6	3·1	4·8	3·5	4·8	...	...
Net lbs. of dry steam per lb. of fuel as fired [1]	14·74	15·05	14·80	15·16	14·75	9·17	8·94

[1] From and at 212° F.

[2] The steam used by oil pump was fraction of one-tenth of 1 per cent., and is therefore not considered.

TABLE II.

COMPARATIVE COSTS OF OIL AND COAL.

	Items.		Bituminous Coals mined West of Ohio, and used in Western and South-western States.	Small Sizes of Anthracite.				Pittsburg bituminous used in Mills of Pennsylvania and on Great Lakes.	Semi-bituminous: Atlantic Ocean Traffic; Mills of Eastern and Middle States.		
				Culm.	No. 3 Buckwheat or Barley.	No. 2 Buckwheat or rice.	No. 1 Buckwheat or pea.		Hand-fired.	Mechanical Stokers and Patent Furnaces.[1]	
										Ash, 10%.	Ash, 5%.
1.	Pounds evaporation per lb. wet[2] coal, from and at 212°, at about 10 sq. ft. of heating surface per boiler h.p.		7·5	7·75[3]	8·25[3]	8·50[3]	8·75	9·50	10·00	10·50	11·00
2.	Pounds evaporation per lb. of Beaumont oil from and at 212°, at about 10 sq. ft. of heating surface per boiler h.p.		14·8	14·8	14·8	14·8	14·8	14·8	14·8	14·8	14·8
3.	Ratio of evaporation of oil to coal = Line 2 ÷ Line 1 = R.		1·97	1·91	1·79	1·74	1·69	1·56	1·48	1·41	1·35
4.	No. barrels oil = to 2,240-lb. ton wet coal = 2,240 ÷ (322[4] R) = N.		3·54	3·64	3·90	4·00	4·12	4·46	4·70	4·94	5·15
	Equivalent price of oil per barrel of 42 U.S. gallons = $P_c \div N = P_o$.										
5.	Price of coal, per ton of 2,240 lbs.	P_c = $1.00	$0.29	$0.28	$0.26	$0.25	$0.25	$0.23	$0.21	$0.20	$0.19
6.		1.50	0.43	0.41	0.39	0.38	0.36	0.34	0.32	0.30	0.29
7.		2.00	0.56	0.55	0.51	0.50	0.49	0.45	0.43	0.40	0 39
8.		2.50	0.71	0.69	0.64	0.62	0.60	0.56	0.53	0.50	0.40
9.		3.00	0.85	0.82	0.77	0.75	0.73	0.67	0.64	0.60	0.58
10.		3.50	0.99	0.96	0.90	0.87	0.85	0.78	0.75	0.71	0.68
11.		4.00	1.13	1.10	1.02	1.00	0.97	0.90	0.85	0.81	0.77
12.		4.50	1.28	1.23	1.16	1.13	1.09	1.01	0.96	0.91	0.87

[1] Mechanical stokers and patent furnaces introducing air over fire.
[2] By "wet coal" is meant coal containing 3 per cent. of water.
[3] These figures are net evaporation after allowing for steam consumed to produce the forced draught necessary for burning the fuel.
[4] Weight of oil per gallon = 7·66 lbs.; weight of oil per barrel of 42 U.S. gallons = 322 lbs.

953. *Manograph (Optical Indicator) of E. Hospitalier and F. Carpentier.* (Ind. Élect. 11. pp. 9–11, Jan. 10, 1902.)—This apparatus is designed to trace indicator diagrams giving the continuous variation of pressure in gas and oil engines at speeds up to about 2,000 r.p.m. An indicator of a similar character was made by Perry, suitable for a steam engine at speeds of 500 or 600 r.p.m. The manograph indicator, Fig. 1, is separated from the motor, to avoid vibrations, and the pressure of the gas is transmitted by a flexible copper tube T, Fig. 2, whilst a flexible connection gives the rotation of the motor-shaft. A little mirror rests on three points A, B, C, forming a right-angled triangle. The point A at the right angle is fixed, and about it the mirror turns; B is moved normal to the plane of the mirror, and in proportion to the pressure, by one end of a rod, the other end of which rests on an elastic metallic disk M, Fig. 2, acted upon by the fluid pressure. The point C moves the mirror in proportion to the travel of the piston. Springs are fixed behind the mirror

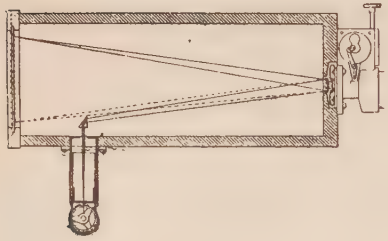


FIG. 1.

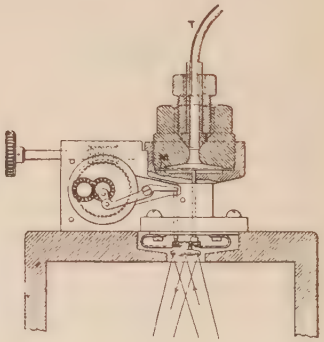


FIG. 2.

to keep it pressed against the three points of support. A beam of light from a small acetylene flame is projected by a prism on to the little mirror, Fig. 1, which reflects it on to a screen, giving diagrams 10 cm. in length and 7 to 8 cm. high. The impressions on the retina make the diagram appear in the form of a continuous curve. Indicator diagrams are given as traced by the spot of light. With very small moving masses, and only slight motion, indicator diagrams are shown from an alcohol motor of De Dion and Bouton, running at 2,200 r.p.m. In an engine having a cylinder 8·4 cm. diameter by 11 cm. stroke the speed was 1,300 r.p.m., and the mean pressure 4·345 kilos per sq. cm. (equal to 61·8 lbs. per sq. in.), while the output of a dynamo driven by it was 3,300 watts. W. R.

954. *Desvignes Ether Vapour Generator.* (Scientific American, 86. pp. 9–10, Jan. 4, 1902.)—This generator consists of two rectangular end chambers of sheet steel, connected by numerous copper tubes slightly inclined to the horizontal, and heated externally by a gasolene furnace placed below the generator. In order to guard against a sudden generation of vapour at very high pressure a safety device is employed, by which the ether is forced out of the generator when the pressure exceeds a certain predetermined value. This apparatus consists of a closed reservoir, normally about half full of ether, and connected to one of the end chambers of the boiler below the ether level by a pipe which projects into the reservoir, and which is closed by a ball valve. Air is pumped into the reservoir, above the ether level, to a

pressure equal to the maximum pressure which is desired in the boiler. If the boiler pressure exceeds this value the ether is driven out of the boiler into the reservoir, the ball valve being lifted by the excess of pressure from below, and kept open, after the boiler pressure has fallen, until the ether level in the reservoir has returned to its normal value. The initial level of ether in the boiler is maintained by a special magnetically controlled device contained in a chamber connected with a vapour drum mounted above the boiler tubes, and connected to one of the end chambers above the liquid level. The main supply to the engine is taken from the vapour drum. After performing its work in the engine the vapour is condensed and returned to the boiler by a feed-pump. The mechanism of a motor vehicle employing an ether generator of this type is illustrated; the generator weighs 265 lbs., and is capable of supplying a 10-h.p. engine. C. R. D'E.

AUTOMOBILISM.[1]

955. *Marks Steam Delivery Waggon.* **J. W. Jones.** (Horseless Age, 9. pp. 49–50, Jan. 8, 1902.)—This vehicle has a tubular underframe, which couples the front and rear axles, and from which the van body is supported by elliptic plate springs front and back. The boiler is of the combined water-tube and fire-tube type, fired by a kerosene burner. The heating surface is 45 sq. ft. Steam at 200 lbs. per sq. in. is supplied to two horizontal compound engines mounted on the underframe and driving the rear road wheels by internal spur gears. The engines have single-acting cylinders and a special form of steam distributing valve operated by a gear of the Marshall type. The only lubrication for the engines is effected by splash from the crank enclosing chambers. The total weight of the vehicle with 50 gallons of water and 18 gallons of kerosene is 4,000 lbs. C. R. D'E.

956. *Flinn's Compound Engine and Steam Carriage.* (Horseless Age, 9. pp. 81–83, Jan. 15, 1902.)—This engine has cylinders 2½ in. and 4¼ in. bore respectively × 4 in. stroke. The cylinders are vertical, and steam is distributed by piston valves located between them. By means of a special distributing valve, high-pressure steam may be admitted to the l.p. cylinder. Its general construction is calculated to secure greater durability than is common with these light steam car engines. The carriage—known as the Volomobile—carries two persons, and weighs 1,200 lbs. with 22 gallons of water and 4½ gallons of petrol. Transmission to the live rear axle is by a single chain reduction gear. C. R. D'E.

957. *Renault Light Carriage.* (Horseless Age, 9. pp. 19–20, Jan. 1, 1902. From La France Automobile.)—The 1902 type Renault carriage with tonneau body to seat four persons is described. It has a single-cylinder vertical water-cooled engine, located at the front end of a rectangular tubular underframe, which is supported from the axles by single plate springs. The engine is enclosed by a bonnet, which forms both tank and radiator of the water-cooling system, the circulation being on the thermosyphon principle. The power is transmitted through a cone clutch to the change-speed gear, which gives three forward and one reverse speed by spur wheels brought into mesh radially, as in the back gear of a lathe. The final transmission is by a jointed tail-shaft to a bevel gear on the live rear axle. Wheel steering operating

[1] Electric Automobiles are described in the Section dealing with Electric Traction.

through a rack and pinion is employed. The change speed and brake levers are mounted on the frame at the driver's right hand. A side and front elevation, and a plan of the arrangment of mechanism are given.
C. R. D'E.

958. *Turrell Gasoline Carriage.* (Horseless Age, 9. pp. 41–42, Jan. 8, 1902. From the Motor Car World.)—In the 1902 type the engine is located towards one side of the channel steel underframe, with centre line of crank-shaft at right-angles to the length of the frame and somewhat to the rear of its centre of length. The transmission is by bore clutch to a change-speed gear in which the spur wheels are always in mesh, and thence by a double roller chain to the exterior of the differential gear on the live near axle. The engine has two horizontal cylinders 4·5 in. bore by 4·5 in. stroke, and is rated at 7 b.h.p. at 750 r.p.m. The underframe in this vehicle has been designed especially with a view to eliminate disturbances of the engine and transmission gear centres. C. R. D'E.

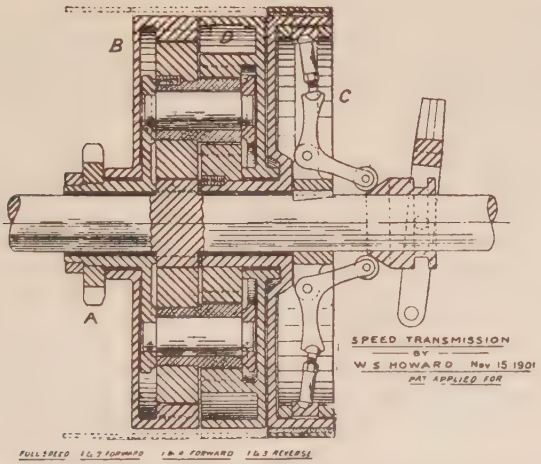
959. *Riegel Fore Carriage.* (Horseless Age, 9. pp. 74–75, Jan. 15, 1902. From La France Automobile.)—This is a two-wheeled tractor which may be attached to the locking plate of any ordinary carriage. Its mechanism comprises a double-cylinder horizontal petrol engine of 10 h.p. and a bevel and spur wheel gearing to the wheels of the tractor, which run on the ends of a fixed axle. The crank-shaft of the motor lies at right-angles to the axle, and carries at its back end the flywheel and at the front end a bevel pinion gearing with a bevel wheel on a counter-shaft parallel to the axle. On this shaft are keyed four spur pinions; these run in mesh with spur wheels which are mounted free on a second shaft, from which the power is finally transmitted by spur gears to the road wheels. The free spur wheels of the change-speed gear may be locked to their shaft by means of electromagnetic clutches supplied with current from a small storage battery of 60 ampere-hours at 4 volts, which also supplies the electric ignition of the engine. The countershaft for the final drive is in halves, and by a special arrangement of clutches either of the road wheels may be driven independently. The vehicle is steered by causing one or both wheels to become drivers. All the operations of the mechanism of the tractor are controlled electrically from the steering pillar, and the connections between carriage and tractor are therefore very simple. C. R. D'E.

960. *Hurtu Light Carriage.* (Horseless Age, 9. pp. 108–109, Jan. 22, 1902. From La France Automobile.)—This vehicle has a rectangular tubular underframe spring from the front and rear axles by semi-elliptic plate spring. The engine, which may be either single or double cylinder, is of the vertical water-cooled type, and is enclosed by a bonnet at the front of the frame. The change-speed gear is of the sliding spur-wheel construction, giving three forward and one reverse speed. It is enclosed in an aluminium gear box, mounted as close as possible to the engine. The power is delivered to it through a cone friction clutch, and is conveyed from the change-gear countershaft by a flexible tail-shaft to the differential, which is suspended in front of and from the fixed rear axle. The differential is coupled by jointed rods to short shafts which run in bearings attached to the fixed axle, and which carry spur pinions engaging with internal spur-wheel rings on the rear-road wheels. The rear-wheel band brakes are applied on the exterior of these toothed drums. Steering is controlled by a hand wheel mounted on an inclined

pillar, and operating through a worm and section gear. The weight of the carriage with body varies from 1,100 to 1,300 lbs. The wheel base is 72 in., and gauge 48 in. All four wheels are 30 in. diameter. Several illustrations of the arrangement of mechanism are given. C. R. D'E.

961. *Howard Speed Change-Gear.* (Horseless Age, 9. pp. 83–84, Jan. 15, 1902.)—This is a compact form of epicyclic gearing giving three speeds forward and one reverse, its construction will be readily understood from the accompanying diagram.

When clutch c is thrown in the gearing is locked, and the full speed of the



engine transmitted to the chain pinion A. For the intermediate speed the clutch is released and a band brake applied to the drum B. For the slowest speed the brake is shifted on to drum D. For the reverse motion the band brake is applied to the exterior of the clutch drum. Note in this article figs. 2, 3, 4, should read figs. 3, 4, 2. C. R. D'E.

962. *Clement Motor Bicycle.* **L. Fournier.** (Locomotion Automobile, 9. pp. 71–73, Jan. 30, 1902.)—In this machine a single cylinder petrol motor is attached to the bottom stay of the diamond frame, the cylinder being within the frame, with its head close up to the steering-post. The flywheel of the engine is mounted externally to the crank chamber at one side, and outside the flywheel is a grooved pulley round which passes a gut band, which transmits motion to the rear wheel of the machine. The driving band passes over a jockey pulley which is mounted on the seat-post. The carburettor is of the float-feed type. Electric ignition is employed. The motor develops 1 h.p. at 1,900 r.p.m. and weighs 7 kg. C. R. D'E.

REFERENCES.

963. *Crank and Connecting Rod Proportions.* **Loppé.** (Soc. Int. Elect., Bull. 1. pp. 555–556, Nov., 1901.)—A note on the ratio K of the tangential force on the crank pin of an engine to the force on the piston, with a table of values of K for different ratios of crank to connecting rod. B. P. S.

964. *Steam Engines for Driving Alternators.* (Soc. Int. Élect., Bull. 1. pp. 557–558, Nov., 1901.)—A schedule, communicated by the Société d'Éclairage Électrique, of conditions which should be kept in view by designers of steam engines intended for the driving of alternators. The points specified to have reference mainly to the permissible range of cyclic variation of flywheel speed, the weight and speed of flywheel, alteration of speed while running by altering the governor weight, &c. B. P. S.

965. *Angular Velocity in Steam Engines.* **W. I. Slichter.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 767–779, Oct., 1901.)—Some calculations on variation of displacement, owing to variations of velocity within the cycle, of engines driving alternators. H. R. C.

966. *Angular Variation in Steam Engines.* **P. O. Keilholtz.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 729–766, Oct., 1901.)—Includes an account of some experiments in which actual variation of speed was measured by means of a tuning-fork trace on paper. H. R. C.

967. *Pumping Engines.* (Eng. Record, 44. pp. 474–477, Nov. 16, 1901.)—An account of the trials of four pumping engines built by the Holly Manufacturing Company. Three of these engines have a capacity of 35 million gallons a day, each, at a lift of 45 ft.; and the fourth has a capacity of 20 million gallons a day at a lift of 125 ft. At the trials the i.h.p. of each of the former was about 323 and that of the latter 464. The average steam consumption was about 11·1 lbs. per i.h.p.-hours. The paper gives full details of the trials. H. R. C.

968. *Transverse Stresses in Steam-pipes.* **A. S. Mann.** (Amer. Electn. 13. pp. 574–575, Dec., 1901.)—Considering the main steam-pipes as beams, the author examines the effect of the branch pipes in causing transverse stresses. H. R. C.

969. *Large Boiler Stoking Plant.* (Engineer, 92. pp. 584–585, Dec. 6, 1901.)—This article gives photographs and sectional drawings of complete coal and ash handling plant for a range of 16 Lancashire boilers, the total quantity of coal capable of being dealt with being 30 tons per hour. F. J. R.

970. *Chimneys.* (Eng. News, 46. pp. 466–468, Dec. 19, 1901.)—An account, with detailed drawings, of several recently constructed steel and steel-concrete chimneys in St. Louis, New York, Cincinnati, and Jersey. H. R. C.

GENERAL ELECTRICAL ENGINEERING.

971. *Electric Ship's Lift on the Dortmund-Ems Canal.* (Engineer, 93. pp. 6–8, Jan. 3, 1902.)—At Henrichenburg the level of the canal falls 50 ft., and vessels are raised or lowered at this point in a ship's lift, consisting of a tank 230 ft. by 28 ft. by 8 ft., capable of floating canal vessels up to 800 tons displacement. The work is done electrically by means of compound-wound-motors. W. H. S.

972. *Cassel's Self-regulating Water Wheel.* **E. C. de Segundo.** (Inst. Mech. Engin., Proc. 4. pp. 1013–1019; Discussion, pp. 1019–1024, Sept., 1901. Paper read before the Glasgow Engineering Congress (Section III.) 1901.)—The author describes in this paper the different atttempts which have been made to improve the water-motor so as to combine efficiency with economy and reliability in its action. After describing the different methods adopted in practice, the author thinks that the key-note to the solution of the problem was struck by the introduction of the deflecting nozzle. Moreover, he points out that satisfactory water-power governing can only be established in two operations—(1) The speed of the water-motor must be controlled without regard to the question of saving water; and (2) the apparatus for reducing the velocity of flow must then be brought into action. The author shows how the solution is worked out by E. F. Cassel. A detailed description of the construction of the wheel and the action of the governing mechanism is given in the paper, which is fully illustrated. From trials made by the author with an 18″ Cassel wheel driving a 5-h.p. dynamo it resulted that when the whole load was thrown on or off suddenly a variation of 1·7 per cent. to to 1·8 per cent. from the normal was perceptible, and the variation may be said to have been practically momentary. It was found that when the head was suddenly varied from 150 to 1,000 ft. the variation of speed did not exceed a momentary variation of 1·8 from normal. This method of construction lends itself to all known types of vertical impulse wheels, and the author concludes that the speed of the wheel can be relied upon to remain constant, irrespective of any variation in head or load.

Discussion.—**A. Barr** mentioned his device of governing by the aid of an adjustible nozzle in the case of low or moderate pressure. **J. Goodman** thought that a combination of Barr's nozzle with Cassel's motor would give good results, as a mere throttling device or a contracting nozzle could not be used successfully for the governing of water-motors. **M. Morrison** wrote inquiring whether larger wheels had been tried, and pointing out that in coupling electrical machinery to the water-wheel the moving parts of the wheel controlled by the governor had considerable inertia and friction, and one would expect a large turbine to take an appreciably greater time than the smaller ones to resume normal speed. He questioned whether the mechanical construction of the larger-sized wheels would not give trouble. The author, in reply to a question by **B. Donkin**, stated that he had never obtained a greater efficiency than 75 per cent., although 92 was claimed for it. He could see no reason why the Cassel wheel should not attain that efficiency. **J. Goodman** said that in testing Pelton wheels he obtained 80–83 per cent. The author said that he did not anticipate any difficulty in obtaining as close regulation in the larger size as he had obtained in the smaller ones. L. G.

GENERATORS, MOTORS, AND TRANSFORMERS.

973. *Modern Commutating Dynamo Machinery.* **H. M. Hobart.** (Inst. Elect. Engin., Journ. 31. pp. 170–217, Dec., 1901.)—The author considers that there should be more difference, in many features, between a 500 volt and a 100 volt machine for the same output and speed, than between two machines of the same voltage and very different outputs. He is satisfied that the magnitude of the reactance voltage per commutator segment is of the first importance in determining the performance of the machine from the commutating standpoint. It is of far more importance to have low reactance voltage per segment than to have low armature strength, as expressed in ampere-turns per pole. The author discusses the variations necessary in designing machines for a given output, but different voltages. He gives sketches, with tables of the principal dimensions and other data, for a line of four machines of 80, 100, 125, and 150 kw., each model being worked out for voltages of 115, 230, and 550. For the entire range of capacities, the cost of the net effective material varies but little from 16·3 shillings per kilowatt. The author discusses reactance voltage at considerable length, and gives a number of tables and curves showing the results of his experiments. He shows that the inductance of the "free length," that is the end connections, is 25 to 40 per cent. of the total ; and with the ordinary open slots with parallel sides, the inductance per cm. of "embedded length," that is, the length in the slot, is only four to six times as great as the inductance per cm. of "free length." Hence the inductance of a coil on a smooth-core armature is rarely less than one-third, and often one-half as great as the same coil laid in a slot. With careful proportion in other respects, one may be sure of excellent results with reactance voltages not over 3 volts. On large slow-speed direct-connected machines the permissible limit for the reactance voltage increases considerably with the size of unit. For speeds of 80 to 100 r.p.m., 3 to 4 volts may be used with perfect success for the range from 400 to 800 kw. The author is unable to explain why the large sizes are less sensitive to high reactance voltages. Tables of data of his own designs for slow speed direct-connected units of 400, 1,000 and 1,600 kw. are given, and the practicability is discovered of obtaining good results as regards sparking in large dynamos for direct coupling to high-speed engines, he considers that it is purely a question of adopting sufficiently solid construction, to permit of an absolutely true running commutator at a high peripheral speed, both commutator and brush supports being completely free from vibration. He considers that one of the most characteristic novelties of his designs consists in the employment of fairly numerous poles combined with high armature strength per pole.

R. B. R.

974. *Design of Continuous-Current Dynamos.* **H. A. Mavor.** (Inst. Elect. Engin., Journ. 31. pp. 218–229 ; Discussion pp. 229–244, Dec., 1901.)—The author gives formulæ for calculating the total e.m.f., the reactance voltage, the average e.m.f. per section c, and the total ampere turns on the armature. He assumes that the ratio c/r has a very important bearing upon the commutating conditions of the machine, and gives formulæ and curves showing the relations between this ratio and the total ampere turns, the depth

of the slot, and the dimensions and speed. He considers that e/r should not be less than 1·6, and there is no advantage in going above 2. It has been assumed that the e.m.f. available for overcoming the reactance voltage may be taken as a definite proportion of the total e.m.f., and for this to hold true the ampere turns per pole should not exceed 10,000 per centimetre length of the air space. He suggests that there ought to be a regular relation between cost and output. This may be obtained by plotting watts per revolution as abscissæ and costs as ordinates. The position of each machine is marked, and the points representing cost and output for each carcase of given diameter and varying length are joined by a straight line, which is produced to cut the zero ordinate at a point which he calls the base cost of any given carcase. Its slope gives the cost per inch length of "active belt" on that carcase. Starting from the smallest diameter and passing to the largest will give a succession of straight lines enveloping a curve of which the tangents are the lines representing each machine, each tangent segment showing the economical range of length for the machine which it represents. A diagram is given to illustrate this. This method is useful up to 100 cm. diameter, beyond this the cost is very approximately proportional to d^2l.

Discussion.—**G. Kapp** gave a formula for calculating the output of a machine, $P = C\left(\frac{D}{100}\right)^2 L\left(\frac{U}{100}\right)$ where P is the output in kilowatts, D = diameter, L = length in cm. C is a constant, which is lower for a high-pressure machine, and also varies with the diameter, it may vary from about 0·6 to 2·6. An approximate formula is $C = 0{\cdot}6 + \frac{D}{200.}$ But the formula is not accurate, because it does not take account of the pressure and heating limit, and for the same reason he was a little suspicious of the Mavor curve. **S. P. Thompson** considered it was only a rough approximation to take the ratio between reactance voltage and average voltage per bar of the commutator. The field for reversing during commutation is not the same as the average field under the pole, nor is it necessarily proportional to it. He discussed the problem of commutation. He considered the comparison of ampere-turns on pole and of the armature winding per pole to be fallacious. Given the density of flux, the speed and time of commutation, for a given type of machine there must be a definite number of amperes per inch of periphery of armature which can be commutated without a spark, which will be independent of the length of the machine and of the number of ampere-turns of excitation required. **W. A. Chamen** felt that the difficulty experienced with commutators in comparatively high-speed machines of large size is mechanical. **R. E. Crompton** mentioned the "Artillery Wheel Press" system of holding and compressing commutator segments into true cylindrical form. The machine consists of a large number of radial plungers worked by hydraulic means, forcing an iron ring inwards, so that the metal is actually upset. This machine has produced most excellent and permanently accurate commutators which give no trouble from subsequent displacement of segment. **W. B. Esson** said that in a former paper he had proposed to call the product of the number of conductors in the armature and the currents they carried the volume, and afterwards Thompson had suggested calling it circumflex. If the circumflex $V = 576lI/\phi$, the forward and cross induction under the pole tips would be equal, when I = induction in air-gap in c.g.s. units, l = length of air-gap, ϕ = angle of pole face in degrees. He recommended that the circumflex should not exceed half this critical value. He said that in Mr. Hobart's 1,600-kw. machine the circumflex was 348,480,

whereas it should be 237,600, so that with 50 per cent. overload the field at the pole tips would be reversed. This shows that when the armature teeth are highly saturated the real air-gap is much more than the apparent air-gap. The magnetic resistance of the cross-field is probably 50 per cent. greater than the apparent air-gap and iron part would account for. **H. M. Hobart** said he found Mr. Mavor's formula for reactance voltage quicker than his own method. He did not pay much attention to shaping pole corners, and considered it was only successful in exceptional cases. With regard to Mr. Esson's remarks he thought that machines might be run with much higher armature strength, provided the reactance voltage was low. **H. A. Mavor** said his formula enabled the designer to calculate reactance voltage without considering any extraneous matters, the value being obtained directly from the watts generated by the machine, its diameter, turns per section on the armature, and average field. R. B. R.

975. *Armature Reaction and Alternator Design.* **J. Fischer-Hinnen.** (Zeitschr. Elektrotechn., Wien, 20. pp. 29–33, Jan. 19, and pp. 41–46, Jan. 26, 1902.)—After briefly referring to the methods proposed by Behn-Eschenburg, Rothert and Potier [see Abstract No. 566 (1902)], for pre-determining the voltage-drop in alternators, the author sketches out his own method. Let X = field ampere-turns; $f(X)$ = corresponding e.m.f.; α = angle of lag of

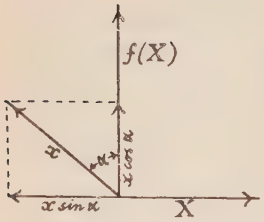


Fig. 1.

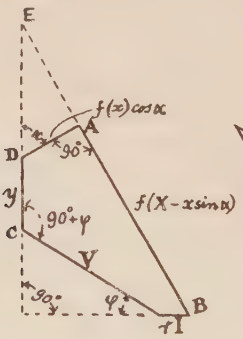


Fig. 2.

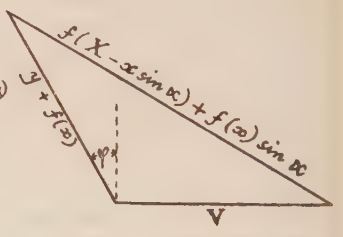


Fig. 3

current behind e.m.f.; x = armature ampere-turns. Referring to Fig. 1, the author splits up the armature ampere-turns into two components, $x \sin \alpha$ and $x \cos \alpha$; the former, which corresponds to the back-turns, is to be subtracted from X; the latter gives the cross-turns. From the open-circuit characteristic we can find the e.m.f.s $f(X - x \sin \alpha)$ and $f(x \cos \alpha)$ corresponding to the ampere-turns $X - x \sin \alpha$ and $x \cos \alpha$ respectively. Since, however, x is small, so that $f(x \cos \alpha)$ lies on the straight-line portion of the characteristic, we may write $f(x) \cos \alpha$ for $f(x \cos \alpha)$. The e.m.f. diagram is shown in Fig. 2, ϕ being the angle of phase-difference between the terminal p.d. V and the current I ($\cos \phi$ = power-factor of load). V may be regarded as the resultant of rI (armature resistance drop), the e.m.f.s $f(X - x \sin \alpha)$ and $f(x) \cdot \cos \alpha$, and y, which corresponds to the leakage induction e.m.f. of the armature. By producing BA and CD until they intersect in E, it is easy to see that $DE = f(x)$, and $AE = f(x) \sin \alpha$. Hence, neglecting rI, which is always small, the diagram may be simplified as shown in Fig. 3. The angle α is, however, unknown in the first instance; it is generally $> \phi$, and as a first approximation

we may put $\alpha = \phi$. The author gives a table of values connecting $\cos\phi$ with $\cos\alpha$. In the special case $\cos\phi = 0$, the p.d. is obtained by subtracting y from $f(X - x)$. Hence, assuming that the open-circuit characteristic (Fig. 4), x and y are given, it is a very simple problem to find the connection between the field ampere-turns and the p.d. for a given value of wattless armature current. The corresponding curve is shown dotted in Fig. 4, and is readily seen to be the open-circuit characteristic displaced through a distance $z = \sqrt{x^2 + y^2}$ in a certain direction. This result had been pointed out by Potier,[9] but the author utilises it for determining the values of x and y. Assuming that the following data are known : (1) the open-circuit charac-

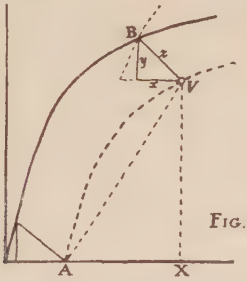


FIG. 4.

teristic ; (2) one value V of the p.d. corresponding to a wattless current I ; (3) the field ampere-turns A necessary to produce the short-circuit current I ; the values of x and y corresponding to the current I may be found thus : Draw the rising portion of the open-circuit characteristic on a piece of tracing-paper, and then slide it along AV parallel to itself until A coincides with V. If through the points V and B two lines be drawn parallel to the co-ordinate axes, then the sides of the triangle so formed give the values of x and y for the current I.—The second part of the paper deals with the determination of the dimensions of an alternator for a given maximum voltage drop. A. H.

976. *Sparkless Commutation with Fixed Brushes.* **C. W. Hill.** (Elect. Rev. 50. pp. 44–47, Jan. 10, 1902.)—The author gives diagrams showing the resultant field with one, two, and three coils short-circuited by the brush, showing that the resultant field is less as more coils are short-circuited by the brush. He also gives formulæ for calculating the resistance voltage in a coil short-circuited by the brush. R. B. R.

977. 1,000-*kw. Tramway Generator.* **Niethammer.** (Elektrotechn. Zeitschr. 23. pp. 45–46, Jan. 16, 1902.)—This is a description of a machine built for the Sheffield Corporation by the Union Elektrizitäts Gesellschaft of Berlin. The machine gives 1,000 kw. at 500–525 volts, 90 r.p.m., with an efficiency at full load of 94·4 per cent., at ¾ load 93½ per cent., and at ½ load 92½ per cent. It has sixteen poles, and the armature diameter is 3·5 metres. A. E. L.

978. *Best Degree of Saturation in Polyphase Generators.* **E. Korrodi.** (Elektrotechn. Zeitschr. 23. p. 47, Jan. 16, 1902.)—In the figures below, *o f b* and *o g b* represent the voltage-excitation curves of two machines with similar armatures, but with the fields working at low and at high density

respectively. Fig. 1 is a comparison of the loads required to produce the same drop of voltage in both machines. Here $e\,a$ represents the reactive ampere-turns—the same in both machines; $e\,f_1$, the self-induction of machine 11 and $e\,f_2$, that of machine 2. Then $a\,b$ represents the drop in voltage common to both machines, while the loads required to produce this drop will be as $a\,f_2$ is to $a\,g$. Fig. 2 is a comparison of the excitation required at the same load, $a\,e$, $e\,f_1$, $e\,f_2$, and $a\,b$ having the same meaning as before, while $f_2\,g$ is

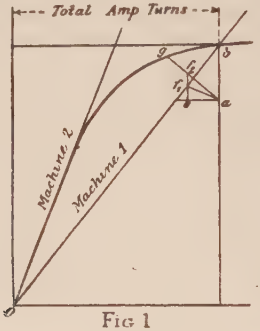


FIG 1

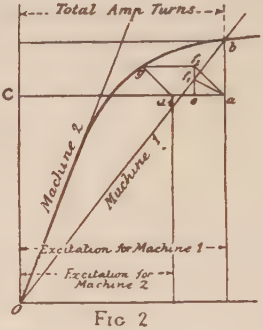


FIG 2

drawn parallel to the axis of x to cut the curve $o\,g\,b$, and $g\,a$, is parallel to $a\,f_2$. Then the excitation required for Machines 1 and 2 respectively will be represented by $c\,a$, $c\,a_1$. While an increase in the density of the fields improves the regulation up to a certain point, a further increase, by increasing the self-induction of the armature, brings f_2 above the curve $o\,g\,b$, so that the regulation is worse than that of Machine 1. A. E. L.

979. *Motor Starting Devices.* **H. C. Heidrich.** (Elect. Rev. N.Y. 40. p. 5, Jan. 4, 1902.)—When current is cut off from a motor by a fuse blowing in the central station the fuse may be replaced before the release magnet of the starting resistance has let go of the arm and put in the resistance. This may lead to damage of the armature if the speed of the motor has fallen low. The sluggish action of the release magnet is due to the shunt motor maintaining its field by generator action, and the author proposes to quicken the action by connecting in the main circuit a relay which, when no current passes, short-circuits the release magnet. G. H. B.

980. *Sychroniser for Three-Phasers.* (Schweizerische Blätter für Elektrotechnik, 7. pp. 10–12, Jan. 22, 1902.)—This paper contains an illustrated description of the synchronising device manufactured by the E. A. G., consisting of a synchronising transformer whose secondaries are divided up into sections connected to a number of incandescent lamps arranged in a circle. The primaries are on one side connected to the 'bus-bars, and on the other to the terminals of the incoming machine, the connections being similar to those used in the Siemens and Halske synchroniser. [See Abstract No. 892 (1899).] The lamp connections are such that the intensity varies from zero to a maximum in a quadrant, there being two diametrically opposite maxima of brightness. The two crescents of light thus formed revolve until synchronism is reached, when they become stationary; the co-phasal relation corresponding to a definite position of the crescents. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

981. *Surges in Transmission Circuits.* **A. E. Kennelly.** (Elect. World and Engineer, 38. pp. 847–849, Nov. 23, 1901.)—Referring to Steinmetz's article on this subject [see Abstract No. 411 (1902)], the author points out that many of the results contained in it are capable of a very simple general explanation. When a short circuit occurs on a transmission line, and is interrupted at a phase corresponding to a large value of the current, the electromagnetic energy associated with the circuit takes the form of electrostatic energy, which again returns to the electro-magnetic form, and so on, until the oscillations are damped out by the resistance of the circuit. Let l and c stand for the inductance and capacity respectively per unit length of the circuit, L for the total length, and I for the value of the current at the instant of opening the circuit. Then we have, neglecting the damping due to resistance, $\frac{1}{2}\,L\,l\,I^2 = \frac{1}{2}\,L\,c\,E^2$, where E is the maximum value of the e.m.f. induced on rupturing the circuit. Hence $E = I\sqrt{l/c}$, from which it appears that the maximum induced e.m.f. is (to a first approximation) independent of the length of the circuit. In the case of overhead lines, l is relatively large and c is small, so that dangerous rises of potential are more likely to occur than on underground cables, for which l is small and c large. As rough average numerical values, the author gives 600 volts per ampere of suddenly interrupted current for overhead wires, and 40 volts per ampere for underground wires, corresponding to the first surge of e.m.f., before appreciable damping has taken place. The frequency of these free surges is such as to make $L\,l\,p = 1/L\,c\,p$, where $p = 2\pi \times$ frequency, and since $1/\sqrt{ol}$ is the velocity with which the electromagnetic waves run through the dielectric, p is numerically equal to the number of journeys that these waves can make in running to and fro along the circuit in one second. For practical purposes the limiting frequency of free surges may be taken as 30,000/L periods per second, when L is expressed in miles. The author points out that such free surges must be carefully distinguished from the stationary waves of p.d. and current in long transmission lines due to *forced oscillations* depending on the frequency of the generator, and produced by resonance effects. A. H.

982. *The Relative Advantages of Three-, Two-, and Single-phase Systems for Feeding Low-tension Networks.* **M. B. Field.** (Inst. Elect. Engin., Journ. 31. pp. 138–158; Discussion, pp. 159–169, Dec. 1901.)—For tramway work alternating motors are at present impracticable; the necessity of efficient speed regulation with large starting torque, and the inadvisability of having more than a single rolling or sliding contact to bring the current into the car, make the direct-current series-motor the only possible one. At the same time, in cases where power has to be transmitted from a single central station to a number of remote feeding centres, high-tension alternating currents may be essential for the transmission. Suitable converters must be placed at the feeding centres for transforming to continuous current at 500 volts. These may be either (1) rotary converters combined with static transformers; (2) synchronous motor generators; (3) non-syn-

chronous motor generators. With rotary converters, the output when used as a D. C. generator being taken as unity, will be 0·825, 1·31, 1·61, and 1·94 when used as a single-, three-, four-, or six-phase rotary respectively. A table is given showing various data of construction and performance (heating, efficiency power factor, starting current, &c.) of rotary converters and motor generators of the two types; and another table with prices, weights, and efficiencies of converter equipments based on estimates given by three or four leading makers. Three- and two-phase rotaries with transformers, three-, two-, and single-phase synchronous motor generators, and three-, two-, and single-phase induction motor generators are the types of plant of which data are given; the single-phase rotary is not included, working, as it does, at such disadvantage compared with the two- and three-phase rotaries. The author gives the preference, all things considered, to the two- or three-phase rotary with transformers as being no more complicated than the motor-generator, and as being, in his experience, unexceptional from the point of view of overload capacity, ease of regulation and manipulation. It is possible, but not easy, to make a well-designed machine of this kind surge. *Cables.*—An exhaustive comparison follows of various cable systems, taking as a basis one mile of three-core cable with earthed neutral, transmitting 1,000 kw. at 6,500 volts, three-phase, the area of each core being 0·15 sq. in. The results are tabulated, the table showing the strains on the insulation of the cables and of the machinery (not necessarily the same thing), the areas of cables for a given loss per mile (6·3 kw.) when transmitting the same power, and cost per mile laid and jointed, including laying of ducts (iron, cement-lined, Glasgow practice), and drawing in. The advantage in point of price is seen to be clearly with the three-phase, three-core system with earthed neutral point, but the author personally prefers an unearthed system, a proper check being kept on the insulation. Board of Trade requirements may entirely modify the results given in the table. Examples are given to illustrate this point. As regards *switchboards*, the simplification effected by employing a single-phase circuit is more apparent than real. In Glasgow the whole value of the switchboards was only one-fifth of that of the whole cable system, so that the saving under this head, which might have been effected by a single-phase system, would have been negligible. *Generators.*—The author obtained prices from different makers for three-phase and single-phase generators, 2,500 kw. at 6,500 volts, 75 r.p.m. and 25 periods, drop at full load (power-factor unity) not more than 7 per cent. The results (weight and cost) are tabulated. The mean figures are—three-phase, weight 111 tons, cost £5,340; single-phase, weight 138 tons, cost £6,595, or an increase in both weight and price of about 23 per cent. for the single-phase as compared with the three-phase machine. Where lighting and power-work are combined, there is, in the author's opinion, something to be said for single-phase. For a three-phase distribution really shows no advantage over distribution by single phase, as any theoretical advantage held by the former is compensated by the fact that the single-phase distribution would, in practice, be by the three-wire system, which would not be feasible in the case of three-phase, owing to the difficulty involved in the independent regulation of the circuits. A three-phase system is alluded to which has been adopted with some success in America and elsewhere, in which to avoid regulation in substations the voltage of one phase alone is kept constant at the generating station, all the incandescent lights of the system being connected across this one phase; the other phases are left to look after themselves. No attempt is made to balance the loads on the three phases; but the effect of motors and trans-

formers is to equilibrate the different loads, the lightly-loaded motors acting to some extent as generators and supplying current to those which are more heavily loaded. In a note the author gives his idea of the lines on which the problem of the employment of three-phase motors for tramway work in crowded cities will be solved—by the combination, namely, of two shallow conduits of the slot-rail type, with surface contacts laid every 2 or 3 ft. Every fortieth contact would control the succeeding thirty-nine, which would be of the simplest character, with no mechanism whatever. Other notes are: a table of power-factors, at full and half-load, for single- and three-phase motors of different sizes, and a table of readings of pressure and current in a test made on a three-phase generator loaded on a three-phase motor, two of the phases being loaded on a non-inductive resistance as well, showing the balancing effect on the three phases of the non-inductive load.

Discussion.—**Kolben** agreed that for metropolitan areas the right thing at present is combined three-phase and continuous-current distribution. The serious objection to the three-phase motor is the question of speed-regulation, which entails larger generating plants and stations than would otherwise be necessary, owing to loss of energy in regulating. This was the case also with direct-current motor systems, until the invention of the series-parallel controller. Apart from the question of economy of running, it is cheaper to instal three-phase generators, with substation converters and continuous-current motors, than to make a three-phase generating station large enough to supply the margin of power required in the speed regulation of three-phase motors. As regards the pressure regulation of a three-phase supply, a difference of even 30 per cent. in the load on the different phases makes a very small percentage difference of pressure between the phases. **H. S. Carhart** thought that a frequency of not much more than 25 would be sufficient for incandescent lighting, and something rather higher than this again for arc lighting; it need not be so high as 50. Open-type arcs are rapidly disappearing in the United States and giving way to enclosed lamps, which can be run in series on a three-phase distribution. In the transitional stage three-phase or synchronous motors are used to furnish power to run the direct high-tension generators for the open-type arcs. **W. B. Esson** observed that three-phase distribution does for alternating current exactly what the three-wire system did for direct current, as regards weight of copper. In future there will be no more single-phase stations; they will be either three-phase or direct current, or (in the case of conversion from single-phase stations) two-phase, for the reason that it is easier to adapt existing systems of mains to two- than to three-phase working. **S. P. Thompson** considered the complication usually considered to attach to three-phase switchboards of connections to be quite imaginary. **Blathy** thought that where accumulators are to be charged motor generators are preferable to rotaries. The best way, however, to run tramways or railways is to drive the motors direct with polyphase currents. The experiments now being carried out on the railway lately built in Italy, until now run by steam, but in future to be actuated by polyphase current (the first of its kind), have proved perfectly satisfactory up to the present. Passenger traffic is to be run at 40 miles an hour, goods traffic at 20. Trains will be run at least as heavy as those formerly drawn by steam locomotives, and probably considerably heavier. The stations are about three miles apart. As to the general question of electric traction, an advantage over the steam locomotive was that the weight of the tender—about 30 tons on the average—is dispensed with, and the torque on the driving wheels is absolutely uniform, instead of varying as between 2 and 3,

as in the case of the steam locomotive, where the adhesive weight consequently has to be sufficient to take the maximum. In the electric locomotive the total adhesive weight is available at every instant for utilising the work of the motors. As regards frequency, the standard has been gradually going down to 42, at which it now stands. Most new stations erected on the Continent have this frequency. **G. Storey** alluded to the advantages of synchronous motors in reducing the lag due to induction motors; but the author thought this an expensive method of attaining the result desired. **W. Geipel** pointed out that with a three-phase lighting system it is possible to use lower voltage lamps, while obtaining the economy of the higher voltage for motors. B. P. S.

983. *Production of Electrical Energy from Carbon.* **W. R. Cooper.** (Feilden, 6. pp. 9–15, Jan., 1902.)—In this paper the author first discusses the saving which is likely to be obtained by the substitution, in generating stations, of the boilers, steam-engines, and dynamos by electrolytic cells consuming carbon directly, *e.g.*, in the form of coke, and having an efficiency of 70–75 per cent. Taking—

Costs of generation	Fuel	1d.
	Other items.....	2d.——3d.
Capital charges ...	Generating station	1·3d.
	Mains	1·1d.—2·4d.
		5·4 pence per unit sold,

and assuming that only $\frac{1}{12}$th of the amount of fuel at present required were used a saving of 17 per cent. would be effected; and assuming the cost of buildings and battery to be $\frac{1}{3}$rd less than that of a steam plant, a further saving of 7 per cent. would be obtained, giving a total probable saving of 1·3d., or 24 per cent. The action of carbon-consuming cells is then discussed, and the Jacques and Blumenberg cells are described. C. K. F.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

984. *Electric Power at Ikervar, in Hungary.* (Soc. Belge, Élect., Bull. 18. pp. 383–397, Nov., 1901.)—In this article a detailed description is given of the hydraulic plant and electrical installation at Ikervar, in Hungary. The power is transmitted to Szombathely and Sopron, and is used for lighting the surrounding villages, for working two lines of tramways, and for other industrial purposes. The water power is derived from the river Raab, a tributary stream of the Danube; the flow of water is about 22 cubic ft. per second, and the total available power is over 2,000 h.p. The power-house is situated about 3 km. from the towns of Ikervar and Sarvar. Five Jonval turbines are erected, of which each is capable of developing about 300 h.p. at 160 r.p.m. Each turbine has coupled direct to its horizontal shaft two 6-polar direct-current Thury dynamos, the high e.m.f. required being obtained by coupling a number of series-wound generators in series on the Thury system. [See Abstract No. 1369 (1900).] The turbines are manufactured by Messrs. Escher-Wyss, of Zürich. The generating plant at Ikervar is divided into two distinct groups. The group A contains three turbines, each driving two dynamos of 97·5 kw. capacity at 1,500 volts, or a total voltage of 9,000. The Szombathely circuit is connected on to this group. The other

group, B, contains two turbines, each driving two dynamos of 100 kilowatts capacity at 2,500 volts, giving a total voltage of 10,000. The Sopron circuit is provided with power from this group. At Ikervar each dynamo has its independent switchboard, and as the demand for power increases or decreases, so the number of dynamos are put on the circuit or cut out by a simple device. The power is transmitted to several substations, where motor-generators are used, so as to provide current either at 150 volts for lighting purposes or at 550 volts for the tramway working or other motive power. On the high-tension lines from Ikervar to Szombathely and Ikervar to Sopron there are a few installations connected, where the motors are put in series, and used for agricultural purposes: ploughing, threshing, tilling, grinding, &c. One of these installations consists of thirty motors, each of 10 to 20 h.p., coupled in series, and they work very satisfactorily. The speed of the motors is kept regular by suitable governors invented by Thury.

The Szombathely high-tension line is about 65 kilometres long, and the total loss in transmission and transformation is 27·5 per cent. The sectional area of the conductors is 70 sq. mm. A telephonic line is fixed, a metre lower than the high-pressure line, on the same posts on which the conductors are carried. The Szombathely substation contains two 130-h.p. motors, each driving two 75-kw. dynamos; another motor of 110 h.p. drives two 74-kw. dynamos. A 50-h.p. motor drives a dynamo of 33 kw. at a voltage of 550 for the tramway line. An accumulator battery of 120 Tudor elements, with a capacity of 540 ampere-hours, is also erected there. As reserve a large steam boiler is put up, which can, in case of emergency, work a 200-h.p. vertical compound engine. The three-wire system is used in the lighting circuit. There are about 8,000 lamps connected. The tramway line is 2,700 m. long; the overhead wire system is applied. The Szombathely circuit provides the current for the lighting of about twenty villages, the most important being Ikervar and Sarvar, which have their own substations. The Szombathely railway station has a 130-h.p. motor, driving two dynamos of 35 kw. output for the lighting of the station.

The Sopron line is about 150 km. long, and the sectional area of the conductors is 80 sq. mm. About thirty villages are supplied from this circuit. The transmission and transformation loss is 27 per cent., the drop per km. being 8 volts. The substation at Soprano contains two motors, driving each two 40-kw. dynamos at 150 volts, and an accumulator battery. A 130-h.p. gas engine has been erected as a reserve. For the tramway circuit there is a motor driving two 41-kw. dynamos, and a battery of 275 Tudor elements is provided. The tramway (a trolley line) is 5,200 m. long. L. G.

985. *Roux Electric Generating Station.* **L. Gerard.** (Soc. Belge. Élect., Bull. 18. pp. 417–434, Dec., 1901.)—Electric energy is distributed from this station to the district of Charleroi, by three-phase high-tension currents, transformed on the consumers' premises to a pressure suitable to the nature of the service required. Details of the foundations, which were of a special nature owing to the character of the site, are fully described. Dimensions and details of the construction of the engines are also given. These are of the compound tandem condensing type by Van den Kerchove, with equilibrium valves of a new and ingenious design by M. Vanderstegen. The steam pressure employed is 135 lbs. per sq. in. With a load factor on the machines of only 18 per cent., the consumption of coal per kw.-hour is about 7 lbs. The engine governors are of special construction designed to permit of parallel

running of the direct-coupled alternators. The three-phase alternators are by Brown and Boveri, of Baden, and are designed for an output of 250 kw. at 6,000 volts, 40 periods, when running at a speed of 400 r.p.m. At this output the efficiency is 92·8 per cent. The exciters are mounted on the same shaft as the alternators, and are each large enough to furnish exciting current to two alternators. In designing the station special means have been taken to avoid crossing of high-tension conductors, and also to permit of the electrician in charge to see the switchboard and machinery at a glance. The means adopted are fully described. The switchboard is of unique construction. It is in pulpit form, the switch handles and regulators being fixed on a nearly flat marble board and the instruments on a vertical board of glass in front of the switches. By this means the attendant can have his hands on the regulators, see the instruments on the glass board in front of him, and the machine hall beyond, all at the same time. The district served by this station embraces the Communities of Seneffe, Godarville, Pont-a-Celles, Gouy, Trazegnies, Roux, forming a total of 28,100 inhabitants. The primary cables have a length of about 32 km., and the secondaries 89 km. A map of the district, showing the routes of the cables, is given. The supply voltage is 220 volts single-phase for lighting, 600 volts three-phase for motors over 5 h.p., and 220 volts three-phase for motors below this power. F. B.

986. *Brooklyn Electric Station.* (Power, N.Y. 21. pp. 1–5, Dec. 1901.)—The station was originally designed to receive four 3,000-h.p. double horizontal tandem alternating-current sets and two smaller sets, making in all 14,000 h.p. The engine-room floor-space allowed was 13,600 sq. ft., or about 1½ sq. ft. per kw. The floor-space actually taken by the first two horizontal 3,000-h.p. sets was 0·415 sq. ft. per h.p., or 0·623 per kw. The first extension consisted of two 4,500-h.p. Westinghouse *vertical* sets, the saving in space being very great. The actual space occupied is 0·27 sq. ft. per h.p., or 0·427 per kw. Had vertical engines been used throughout, it would have been possible to install 5 units of 4,500 h.p., or a total of 22,500 h.p., in the space intended for 14,000 h.p. This shows the difference in American practice in 1897 and 1901. Details of the engines are given. The maximum pressures on the cross-head and crank-pins are 1,200 and 1,000 lbs. per sq. in. respectively, and on the main bearings 250 lbs. With a steam pressure of 165 lbs. per sq. in. and a vacuum of 26 in., the guaranteed steam consumption is 15 lbs. per i.h.p. at ¾ load. [A full description of the engines is given in *Power*, March, 1901.]

The condensing plant and piping is so arranged that the condensers and air pumps are interchangeable, and may be used in connection with either engine, or with either side of each engine in the event of one side being run as a simple condensing engine. The automatic valves for atmospheric exhaust are provided with air cushions. The lubrication of all bearings is effected by means of a pneumatic oiling system, pressure for which is furnished by a direct driven air compressor, which also supplies compressed air for cleaning boiler tubes and armatures, and other work. The coal- and ash-handling plant is very complete, and is described. The system of generation is three-phase alternating at 6,600 volts. Plan and elevation of the station are given, showing the plant and piping arrangements. F. B.

987. *Maidstone Electricity Works.* (Elect. Engin. 29. pp. 6–10, Jan. 3, 1902.)—The three-wire continuous-current system is employed; 230 volts each side. The steam generating plant consists of four Davey, Paxman & Co.

multitubular boilers, each capable of evaporating 6,000 lbs. of water per hour. Working pressure 160 lbs. per sq. in. The main steam pipes are in duplicate, but all valves are in the branch pipes. The feed-pumps and pipes are in duplicate. The surface condensing plant can deal with 18,000 lbs. of steam per hour. The electric generating plant comprises four 150-kw. and one 75-kw. dynamos, each coupled to a "Peache" engine, the larger sets running at 375 r.p.m., and the smaller at 420 r.p.m. The balancing and charging is done by a combined balancer and booster, consisting of four machines coupled together, the two outer ones being the boosters. The shunt regulating switches for all machines are fixed in a polished teak rail in front of the switchboard, the latter being of Messrs. Kelvin and White's make. A set of 280 chloride cells in glass boxes forms the battery, which has an output of 100 amperes for five hours, or 300 amperes for one hour. The distribution is on the Callender solid system, by the three-core pilot-cable; the arc-lighting mains, and the services to the consumers are armoured with steel tape and laid direct in the ground. The feeders, of which there are six, contain only two conductors, and two neutral feeders are laid. Mains are laid in 5 miles of streets. Sizes and details are given. The load is equivalent to over 9,000 8-c.p. lamps. Details of the chimney and of the foundations, which are of a special nature, are also given. F. B.

988. *Crystal Palace District Electricity Works.* (Electrician, 48. pp. 449–452, Jan. 10, 1902.)—After the boiler explosion in July, 1900, the works were shut down for some time, and various alterations were made. The article describes the present state of the station. The engine-room is 79 ft. by 32 ft. 6 in., and the boiler-house is 57 ft. long by 30 ft. wide. The chimney is 110 ft. high, the internal measurement being 6 ft. square. The three boilers are by Hornsby, each being of 276 nominal h.p. The 9-in. steam main is arranged on the ring principle. The generating plant includes three 210-kw. sets, and two of 90 kw., and one of 45 kw., giving their outputs in direct current at 1,000 volts. There are ten substations in all, at six of which batteries are installed which have a total maximum discharge rate of 180 kw.; the remaining four substations are worked on the Oxford system, and switched in from the works by means of three-core pilot wires. The largest substation is at the Crystal Palace, and contains four 70-kw., three 40-kw., and two 66-kw. fixed ratio E.C.C. transformers in addition to a battery. The high-tension feeders vary from 0·25 sq. in. to 0·06 sq. in. in sectional area.
W. H. S.

989. *Lighting System of the Chicago Edison Company.* (Elect. Rev. N.Y. 40. pp. 42–52, Jan. 11, 1902.)—In this system, a track of country extending 26 miles N. to S. by 10 miles at its widest part is supplied with current. The city limits are supplied with direct current from underground mains, outside this the supply is alternating current at 60 cycles. This network is supplied from a number of stations and substations, of which the Harrison Street Station is one of the most important. Here the boilers are of the Heine water-tube type, 7 of 500 h.p. and 17 of 570 h.p., with Babcock and Wilcox automatic stoking chain grates directly supplied with Illinois screenings through chutes from overhead storage-bins, to which the coal is taken by conveyors from boats or railway trucks. There are four steel smoke-stacks each 180 ft. high by 12 ft. in diameter. The generating plant comprises two double-current and two direct-current units, each consisting of two 200-kw. generators, coupled to the two ends of a Southwark triple-expansion, vertical

marine-type engine running at 150 r.p.m. These double-current machines give 150 volts on the direct-current side, and three-phase alternating current on the other side. There are also six 1,200-h.p. sets generating direct current; a 2,500-kw. double-current generator, capable of working up to 3,200 kw. for three hours, giving 300 volts on the direct-current side, and six-phase, 25-cycle current on the alternating-current side at 75 r.p.m. This is mounted at the middle of the crank-shaft of an Allis vertical cross-compound engine of a maximum output of 5,000 h.p. The armature is 21 ft. 8 in. diameter, the commutator 15 ft. diameter with 960 bars and 560 brushes; there are 40 poles. A 3,500-kw. alternator is being erected, which will give three-phase current at 9,000 volts, and a frequency of 25, which is to be the standard for the system. There are also transformers to step up the current for transmission to outlying substations. The capacity of the station is at present 17,800 kw., the ultimate capacity is to be 27,000 kw. Outside the central direct-current service, distribution is by means of an alternating current at a frequency of 60 on a four-wire three-phase system, having a maximum of 2,400 volts between the neutral point and any one of the outside terminals. At the Lake View Station, 9,000-volt, 25-cycle, three-phase current is received from the Harrison Street Station and transformed by motor-generators to three-phase, 60-cycle alternating current at 2,400 volts between the neutral or fourth wire and any outside terminal. This station supplies current at 5,000 volts and 60 cycles to the Edgewater Station 4 miles away.

The distribution to the western district is on the three-phase four-wire system. The southern district of about 65 square miles is supplied from a station in 56th Street on the three-phase four-wire system [see Abstract No. 579 (1902)]. An example of the direct-current supply substations is the Dearborn Street, in which there are three 500-kw. 8-pole rotary converters, receiving six-phase alternating current, and feeding direct current into the outsides of the three-wire, low-tension, direct-current network. There are also 9 transformers receiving 9,000-volt current from the Harrison Street Station, and feeding six-phase current at the required voltage and phase. In the Adams Street substation there is a 22,400 ampere-hour (at 8-hour rate) storage battery of the chloride type, with a maximum current of 11,000 amperes for 1¼ hours. Each cell has 87 plates (15½ in. by 32 in.), and weighs 6,200 lbs. The field regulation of the charging dynamos at Harrison Street is governed by rheostats, controlled by small motors worked from the switch-board of the Adams Street Station. The total light and power load was equivalent, in September, 1901, to 1,100,000 16-c.p. lamps, of which 69·2 per cent. was for lighting, and 30·8 per cent. for power. The Wright maximum demand system is used. The capital is six million dollars. C. K. F.

990. *Central Station of the Syracuse Lighting Company.* (Elect. Rev. N.Y. 40. pp. 109–112, Jan. 25, 1902.)—The station stands upon the bank of the Erie Canal, about half a mile from the centre of distribution for light and power, and is so situated that it has also convenient delivery for coal by railway as well as unusual facilities for the reception of fuel from boats on the canal. The motive-power equipment is entirely of the steam-operated type. The boiler-room contains eighteen return tubular boilers set in brick, each 6 ft. in diameter by 17 ft. long. Hand firing is used. The water is pre-heated and filtered. The steam-driven units consist of three McIntosh and Seymour vertical compound engines, two of these units being coupled directly with 600 kw. three-phase, 60-cycle, 2,400-volt alternators of the general electric type,

and one of them to a single-phase alternator of the same capacity and frequency. In addition to these units there is a McIntosh & Seymour horizontal cross-compound engine of 1,500 h.p. direct-coupled with an 850-kw. direct-current generator and two engines of the Allis type, one of 500 h.p. and one of 1,000 h.p., belted through a countershaft to a group of arc generators. Two exciters, each of 50 kw. capacity, are direct-coupled to synchronous motors, and there is also a 200-kw. and 500-volt rotary converter. No less than 1,800 h.p. is required for motors, which are mostly operated on the 500-volt direct-current circuit. Lighting is accomplished from the different phases of the three-phase supply, operated at 2,300 volts from the station, and the current appropriately transformed by means of transformers. Arc lighting is effected by means of direct-current apparatus. For generating the direct-current for this purpose, there are installed twenty-three 50-light General Electric machines, and two Brush 125-light arc machines. For street illumination 1,350 series arc lamps of nominal 2,000 c.p. are in use. Connected with the company's general distribution system are the equivalent of 95,000 16-c.p. incandescent lamps. The article is well illustrated with photographic views, showing different parts of the works and installation. J. L. F. V

991. *Newcastle-upon-Tyne Electric Tramways.* (Tram. Rly. World, 11. pp. 1–12, Jan., 1902.)—Details of special foundations due to the nature of the ground, and special building work due to the bricklayers' strike are first given. The total length of route is 16½ miles of double track, the maximum gradient 1 in 13½, and the sharpest curve has a radius of 40 ft. The rails are in lengths of 45 to 60 ft., and are of steel, having not less than ½ per cent. of carbon. They are 7 in. high and 7 in. wide in the base, and 2 in. broad in the head. The fish-plates weigh 73 lbs. per pair. The rails are laid on a concrete bed extending 18 in. outside the tracks, and are held together by steel tie-bars 2 in. by ⅜ in. In many places the streets have been re-paved from kerb to kerb, principally with Jarrah wood blocks, but in some places by granite setts 6 in. deep. The whole construction of the road and track is very substantial, and cost £18,000 per double-track mile. The feeder ducts, which are of fire-clay or cement, are laid under the road bed between the tracks. The manholes are 400 ft. apart. The rails are bonded with 8 in. flexible bonds, equal in section to 0000 B and S, and are cross-bonded with a wire of the same section at distances of 90 to 135 feet. The poles for the overhead equipment are spaced 120 ft. apart, and vary in height from 27 ft. 9 in. to 31 ft.; and in diameter from 6 in. to 9 in. at the base, and from 4 in. to 5½ in. at the top. The first equipment of cars includes 60 of the single-deck bogie type with 8 wheels, 20 single-deck cars on four-wheeled trucks, and 65 double-deck cars on four-wheeled trucks. The wheel base of the single-truck cars is 6 ft., and of the double-truck 15 ft. In the power-house three main generating sets are at present installed, of which the engines are of the vertical inverted type. The largest is a triple expansion engine of 2,000 i.h.p., running at 90 r.p.m., with a steam pressure of 165 lbs. per sq. in. The other two engines are of 1,000 i.h.p., each running at 90 r.p.m. The air-pumps for the condensers are worked from the high-pressure cross-head in the case of the large engine, and from the low pressure one in the case of the smaller sets. Condensing water is obtained from the River Tyne, a quarter of a mile from the generating station. In a pumping-station on the quay two large centrifugal pumps force the water through a 24-in. pipe to the power station, against a head of 90 ft. After passing through to the condensers, the water falls by gravity through

another 24-in. pipe to the pumping station, where it is used to drive two turbines mounted on the same spindles as the pumps. Two electric motors supply the power required, in addition to that developed by the turbines. The large electric generator has 12 poles, and is rated at 1,300 kw., and can give 50 per cent. overload. The two smaller machines are of the 10-pole pattern, each rated at 650 kw. The combined efficiency is 85 per cent. The current is direct at 500–550 volts. Coal is delivered by means of a railway siding, carried on a lofty steel viaduct, into the top of the building directly above the firing floor, where the coal is discharged into overhead bunkers, and is then fed by gravity, through automatic weighers, into the mechanical stokers. Good photographs of the track during construction, of the power station, and of the cars are given, also a sectional elevation of the power station, sections of the rails and bonds, and a plan of the district served by tramway system. F. B.

992. *The Metropolitan Electric Railway, Paris.* **Détroyat.** (Soc. Int. Élect., Bull. 2. pp. 136–155; Disscussion, p. 155, Feb., 1902.)—The service is one of 550 volts continuous; the current is picked up by cast-iron slides running on an insulated third rail of hard steel, to which the current is brought by cables (bare or insulated) from the feeding centres. The lighting is by series of five 110-volt lamps. Special means are provided by duplicating circuits, &c., to prevent the possibility of panic through total extinction of the light. The generating station at Bercy was described in Abstract No. 1819 (1901), but many additions and modifications have since been made. The auxiliary dynamos consist of the exciter sets and boosters. The former are rotary transformers, two dynamos on the same shaft connected by an elastic coupling. They are each of about 65 kw. capacity, and transform the 600 volts down to 130 volts continuous; they are excited in shunt. The low-tension current serves to excite the alternators, and for the works lighting. The boosters, each of 200 kw., transform the generated continuous pressure from 0 to 25 volts, or continuously up to 150 volts, according as the battery is acting as a regulator or is being charged. The motors of the boosters are shunt excited, the generators being compound wound; the series winding is traversed by the full battery current; the shunt winding, connected to the bus-bars on the switchboard, through a rheostat, allows either of balancing the battery according to the pressure of distribution, or of raising the pressure for charging. The converter sets, each of 750 kw., consist of three static monophase transformers, 5,000 to 430 volts, and a rotary converting the alternating current at this latter pressure to direct current at 600 volts. The transformers are delta-connected on the primaries, the secondaries being independent; they are artificially ventilated. The rotaries have six rings on the alternating side, connected to sections on the armature 60° of phase apart. The speed is 250 r.p.m. They are started on the direct-current side; efficiency, 88 to 90 per cent. The battery is of 270 elements, and has a capacity of 1,600 ampere-hours at the one-hour rate; for twenty-four hours its capacity is trebled, and it can easily debit 3,000 amperes for short periods. *Converter Substation.*—The equipment here is similar to the converter equipment at the generating station, and transforms from 5,000 volts alternating to 600 volts direct current. One of the four sets is connected delta-wise on both sides, and runs at 300 r.p.m., but no difficulty on this score has been experienced in regard to paralleling. When the line was first operated the Bercy station was not ready, and a temporary supply of current was obtained, first from the Parisian Compressed Air Company (direct current) and later from the Moulineaux and Asnières Companies (5,000 volts, three-phase,

25 periods). Since November 1, 1901, to January 15, 1902, the Bercy station has been in operation, and has been sufficient for the requirements of the line. Since then, however, owing to the increase of traffic, it has been again necessary to call in the assistance of the Moulineaux and Asnières Companies; a new substation has been put down at the Louvre, to serve the part of the line between Bercy and the Étoile, and for the line between Bercy and Vincennes a feeder has been installed. *Generators.*—The capacity of the generating station at Bercy is now being increased, a 1,500-kw. three-phase generator set being in process of erection, with three new sets of 2,100 kw. on order. These are condensing plants, and by means of superheating, &c., it is hoped to obtain a consumption of 5 kg. of steam per i.h.p.-hour. Curves are given of the line current, the highest point touched being about 2,500 amperes, and also battery charge and discharge curves. On No. 1 line the number of trains running is as follows: 5.30 a.m. to 9 o'clock, 28 trains of from 4 to 7 coaches; 9 to noon, 26 trains of 4 and 5 coaches; noon to 3, 26 trains of 4 to 7 coaches; 3 to 8, 28 trains of 4 to 7 coaches; and 8 to half an hour after midnight, when the service ceases, 12 trains of 4 coaches. The rolling stock, as originally installed, consisted of units of 4 coaches, namely, a locomotive and three trailers. Each locomotive carried two series motors with spur gearing, each of 100 h.p., worked by a single series-parallel controller, with magnetic blow out; the usual safety devices, cutouts, fuses, and lightning arresters being provided. The collectors by which the current is picked up are carried by two connecting rods which permit of a certain freedom of movement both vertically and also sideways for negotiating curves. Owing to the increase of traffic it became necessary to be able at will to increase the size of the trains. This was effected by fitting each locomotive with controllers which will allow either two or four motors to be used at will, so that two of the original units can be worked together. The arrangement, designed by the Thomas-Houston Company, is described. The brakes are worked by compressed air, the compressors being operated by series motors at 550 volts. Tests were made, December, 1900, on a train of three coaches and one locomotive driven by two 100-h.p. Westinghouse motors. Starting from rest, with the motors in series, a speed of 6·5 m. per second was attained in 46 seconds, the current in the full-speed position being 150 amperes (at the twentieth second) and then dropping to about 75; the motors being then put in parallel, the current rose to 300 amperes at the fifty-seventh, dropping to 220 at the sixty-third second, by which time the speed had reached 9.5 m. per sec. The current being then shut off, the speed decreased uniformly to 6 m. per second at the hundredth second, when the brakes were applied and brought the train to rest in 5 seconds. The curves show that the energy lost in the resistances was 19 per cent. of the total consumption. The specific consumption is 49 watt-hours per tonne-km. A similar test made a year later gave the same result. For lighting, and for working the compressors, about 3 watt-hours must be added, giving a total of 52 watt-hours per tonne-km. This figure is somewhat high, but is reduced by increasing the tonnage of the trains, which is the present tendency. The total output of the generating station in direct current during December, 1901, was 1,047,568 units, of which 86·1 per cent. was for traction, and the rest for lighting. The total output per train-km. was 3,547 units, and 61 watt-hours per tonne-km. Comparing this with the actual consumption per tonne-km., viz., 49 watt-hours, the loss in the line is seen to be over 14 per cent. More recent tests give a loss of about 12 per cent. The signalling arrangements are worked electrically, on the automatic block system. Each train as it passes any signal

depresses a lever which actuates this signal, leaves the last one at danger, and re-sets the one before that at "line clear." There is also telephonic communication between all parts of the line. The paper concludes with a description, accompanied by a map, of the proposed extensions of the line. The estimated power necessary for the working of the line, including these extensions, will be 30,000 kw. three-phase. During the year 1901 the total number of passengers carried was over 48 millions, or more than 3½ millions per km.

B. P. S.

993. *Hannawa Falls Electric Power System.* **W. C. Johnson.** (Amer. Soc. Mech. Engin., Trans. 23. No. 919. pp. 131–150, Dec., 1901.)—The author describes the hydraulic installation of the Hannawa Falls Water Power Company, which has acquired the land and water rights along the Raquette River, drawing its water from the drainage of the elevated forests of the Adirondack Mountains. The Raquette River drains an area of upwards of 1,100 square miles, and is further remarkable in that it has a drop of about 300 ft. in the first 3 miles of its course below Colton, and a further fall of 85 ft. in the next 2 miles of its course. The lower 85-ft. fall has been developed first. A dam has been built at the village of Hannawa Falls, which forms a pond 2½ miles long, and covering about 200 acres. From this pond the water is conducted by a canal about 2,700 feet long to a forebay, thence by penstocks to the wheels. The tailrace extends about 2,000 ft. down from the power-house, being separated from the river by an embankment of earth and stone. The location of the dam, forebay, power-house, and the general plan of the dam and entrance to the canal is shown by illustrations accompanying the paper, and a general description of the different parts and the materials used for their construction is given by the author. The dam was completed in 1899, and has had 4·5 ft. of water on its crest in two different seasons. The canal from the dam to the forebay, about 2,700 ft. in length, is 20 ft. in depth from the top of the banks, the bottom being 14 ft. below the crest of the dam. The bottom width of the canal is 30 ft., the top width 110 ft., making the inside slopes 2 to 1 in all cases. The section of the canal was made to carry 2,500 cubic ft. per second of water, with a velocity of 3 ft. per second, it being the intention to use that quantity of water when available. The canal ends in a forebay, in the walls of which there are embedded the ends of seven penstock pipes, six 10 ft., and one 6 ft. in diameter, leading down to the power-house on the bank of the river below. The power-house, which is 250 ft. long, and 60 ft. in width for one-half of the length, and 75 ft. for the rest, is two stories high, and has been built between the water of the river and the face of the high bank. The tailraces have been excavated so that the water in them stands 12 ft. below the floor when the wheels are running, giving a working head of 84 ft. on the wheels. The building is constructed entirely of Potsdam sandstone and steel. The lower floor of the building, a room 115 ft. long and 75 ft. in width, is the electric station, containing a 1,250-h.p. water-wheel, fed by a 6-ft. penstock as mentioned, to either end of which is direct-coupled a 350-kilowatt, three-phase, 4,400-volt generator. Underneath the north end of this room is one of the 10-ft. penstocks, in which there are three openings for receiving three wheels similar to the one described. To each of two of these wheels will be connected two generators similar to these now connected to the wheel mentioned; the fourth will be provided with an extension shaft, to which will be belted an air compressor and other machinery. The water-wheel consists of two runners of American type on the same shaft, discharging outward. The

water is discharged through quarter turns and draught tubes to the tailrace. The speed is regulated by a Lombard governor geared directly to the gate rigging. The wheel and generators run at 350 revolutions per minute. The two 350-kilowatt generators are of the revolving field type, having 24 poles, and delivering three-phase current at a frequency of 60 periods per second and a pressure of 4,400 volts. The Hannawa Falls Water Power Company owns the electric lighting plant in the village of Potsdam, 4½ miles from the station. A double line has been built, each line consisting of three cables of seven strands each of No. 10 aluminium wire. This line was figured to transmit 375 kilowatts with a drop of 400 volts, delivering 4,000 volts at Potsdam. The 20,000-volt line is intended to run to the village of Canton, 10½ miles from the station, and thence to the city of Ogdensburg, 19 miles further. For lighting the station and local distribution 220 volts will be used. All of the lower floor of the power-house building not occupied by the electric station, and the whole second floor, will be occupied by a ground wood pulp mill of a capacity of 100 tons per day. The mill has been arranged for the purpose of utilising the spruce wood available in the region tributary to the Raquette River, and the great pulp wood district of the province of Quebec. The principal industry for which the Hannawa Falls Water Power Company are using the water power is the manufacture of wood pulp. The author describes fully the different manipulations and machines used in the manufacture, and the necessary precautions taken in order to ensure the regular supply of pulp at the rate of 100 tons per day as stipulated. In the grinder-room are placed two pairs of water-wheels of 3,500-h.p. capacity each, on horizontal shafts, supplied with water from two independent 10-ft. penstocks, and discharging into a common tailrace. A storehouse is located about 320 ft. from the power-house, and piling ground, sawing, and barking buildings are provided. The entire plant has been designed and built under the personal supervision of the writer of the paper. The paper is fully illustrated.

L. G

994. *La Goule Power Plant.* (Amer. Electn. 14. pp. 57–61, Feb., 1902.)—A description of a single-phase power and lighting plant on the French-Swiss frontier. The plant consists of three turbines of 500 h.p., and one of 650 h.p. built by Escher, Wyss & Co., and working under an effective head of 85 ft. 3 in. Their efficiencies are 79 per cent. at full load and 80 to 81 per cent. at three-quarter load. The alternators are coupled directly to the vertical shafts of the turbines, and generate at 5,500 volts, with a frequency of 50 cycles per second. The longest high-tension line is to the town of Renan, 12 miles distant. There are eleven substations in various towns, with distributing networks to the smaller villages. The charge for private lighting is 1·40 frs. per annum per candle-power, while, in factories, a charge of 10 frs. per annum is made for a 10-c.p. lamp. The charges for motors vary, according to size, from 536 frs. to 325 frs. or less per h.p. per annum.

A. E. L.

995. *Accumulator Substation at Milan.* (Elettricista, Rome, 11. pp. 33–39, Feb., 1902.)—The old steam generating station of St. Radigonda in Milan has been converted into a substation containing two large batteries of accumulators and rotary converters which take power from the three-phase transmission line from Paderno. The first battery supplies current at 550 volts for the Milan tramways, and has sufficient capacity to run the whole system for an hour. The second supplies at 125–135 volts for lighting

purposes. The tramway battery is composed of 260 Tudor cells 192 R, and has a capacity of 3,464 ampere-hours for a one-hour discharge. The maximum discharge rate is 6,000 amperes. Each cell contains 12 positive plates, each of which is divided into two portions 35 × 78 cm. with a central support. The cell is 95 cm. long by 80 broad by 102 high, and weighs 2·2 tons.

The lighting battery is divided into four portions, each composed of 78 Tudor cells 256 R, and having a capacity of 4,624 ampere-hours for a one-hour discharge. The lighting is supplied on the three-wire system at 125 volts on each side. The two sides are, however, very unequally loaded, so that three of the batteries are joined in parallel on one side and the fourth on the other. Each cell has 16 positive plates of the same size and construction as those in the tramway battery. The dimensions are 95 × 108 × 102 cm. and the weight 2·6 tons. Each battery is in series with a booster by Thury, with automatic field regulation. G. H. B.

996. *Shawinigan Falls Electric Power System.* **W. C. Johnson.** (Elect. World and Engineer, 39. pp. 259–262, Feb. 8, 1902. Abstract of a paper read before the Canadian Society of Civil Engineers.)—These falls, on the St. Maurice River, are some 90 miles from Quebec and 84 miles from Montreal. A canal about 1,000 ft. long, 100 ft. wide and 20 ft. deep leads to the penstocks, which will be six in number, are 9 ft. in diameter, increasing to 11 ft. at a distance of about 50 ft. from the turbines, and are built of soft steel plates $\frac{3}{8}$ in. thick at the upper end and $\frac{9}{16}$ in. at the lower. The available head is nearly 130 ft., and the available h.p. seldom less than 200,000. Each penstock opens into the side of the case of a pair of "Francis" turbines on a horizontal shaft, capable of developing 6,000 h.p. and running at 180 r.p.m. The wheel-case is 16 ft. in diameter, with 31 ft. between the outside bearings. The runners, of gun-metal bronze, are 6 ft. in diameter, and discharge through a central draught tube. The guide-chutes are of cast steel. Where the penstocks enter the power-house they are held against movement from expansion and contraction, a cast-iron bracket, 12 in. deep, encircling the penstock and riveted to it, fitting closely on each side of the 6-ft. wall. Speed regulation is effected by means of gates in the draught tube, controlled by a hydraulic governor. The turbines will be stopped and started by means of a ring gate, on the outside of the guides, operated by an electric motor controlled from the switchboard gallery. Each turbine is coupled to a revolving-field generator capable of an output of 3,750 kw. at 2,200 volts, two-phase, with a frequency of 30. Exciting current is supplied to all the generators from a single dynamo driven by a pair of 500-h.p. turbines. A number of illustrations accompany the paper. G. W. DE T.

997. *Electric Plant at the Natural Food Factory, Niagara Falls, N.Y.* **A. B. Weeks.** (Elect. World and Engineer, 39. pp. 278–282, Feb. 8, 1902.)—Current is obtained from the Niagara Falls Power Co., at 2,200 volts, two-phase alternating. Two-phase induction motors are used for most purposes, but for the lifts, continuous current, transformed by means of rotary converters, is used. Stationary transformers reduce the pressure to 110 volts for lighting and 440 volts for power. A 1-ton electric crane is operated by means of three two-phase induction motors. Double-throw switches are used to reverse the motors. The machinery and processes employed in the manufacture of the principal product—the shredded wheat biscuit—are described, and fully illustrated by photographs and diagrams.

All heat for cooking is supplied by electricity. A miniature electric railway, for the purpose of serving luncheons to visitors, runs around the balcony of the main floor. It is equipped with tracks, switches, stations, and guards. On taking a seat at a station the visitor writes out an order, places it on the car, and presses a button. This lights a lamp on the switchboard in the kitchen. The switchboard operator closes the switch in connection with this station, when the car immediately proceeds to the kitchen. The order completed, the car automatically returns to the station from which it started, bearing the luncheon, and itself serves as a table for the convenience of the visitor. The block system is used, and accidents are not possible. F. B.

998. *Pont St. Martin Hydraulic Power Station.* (Elettricità, Milan, 21. pp. 87–91, Feb. 9, 1902.)—The station has been built by the Società Industriale Elettrochimica, with a view to the supply of power in the Canava and Biella valleys. Water is taken from the Dora Baltea by a concrete dam 90 metres long, and a canal 800 metres long, and 16·8 square metres in section. The slope is 0·06 per cent., and the velocity of flow 1·8 metres per second. Four turbines by Riva Monneret & Co., with horizontal shafts are coupled directly to four three-phase generators by Schuckert. The pressure of 3,000 volts at the generator terminals is raised to 15,000 volts by transformers also by Schuckert. The pole line, consisting of six wires, transmits the power a distance of 30 kilometres, the line having, with its distributing branches, a total length of 70 kilometres. The pressure is reduced by transformers to 500 volts. G. H. B.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

999. *Use of 45-feet Rails.* **T. R. Coates.** (Street Rly. Rev. 11. pp. 849–851, Nov., 1901. Paper read before the Roadmasters' and Maintenance of Way Association, Washington D.C., Oct. 1901.)—Practical use of rails longer than 30 ft. has been made on 34 out of 128 American railroads, the lengths varying from 31 to 62 ft. The majority of the rails are 33 ft. long, and represent a mileage of 14,000 miles. Thirty-three feet has been recommended by the above Association and by the *American Railway Engineering and Maintenance of Way Association*, as a standard. As regards cost, whereas one man can straighten a 30-ft. or a 33-ft. rail, it takes four men to handle a 60-ft. rail, and it is almost impossible to say whether it is straight or not. First cost, therefore, is greater with the 60-ft. rail. The cost of maintaining the joints is also greater in the case of the 60-ft. rail, owing to expansion and contraction. The 45-ft. rail reduces the number of joints by 33 per cent. of the number required for 30-ft. rails. If properly laid, special precautions having been taken to provide for expansion, a track with 45-ft. rails will ride better than one with 30-ft. lengths. The cost of lining and surfacing 45-ft. rails is slightly in excess of the cost with 30-ft., although there is a little saving in maintenance. F. B.

1000. *Chemical Treatment of Ties for Railroads.* **J. E. McNeil.** (Street Rly. Rev. 11. p. 846, Nov., 1901. Paper read before the Roadmasters' and Maintenance of Way Association at Washington D.C., Oct., 1901.)—The results are given of tests of the zinc-tannin or Wellhouse process of timber

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

preservation. The object of the tests was to ascertain if the hardness of wood ties or the holding power of the spike were increased by the above chemical treatment. It was found that whilst the hardness of the wood was not increased, its density and transverse crushing strength were increased in proportion to the amount of chemical absorbed, which is about 30 per cent. in coarse-grained pine. The holding power of the track spike is also increased by 30 per cent. F. B.

1001. *Dangers from Trolley Wires.* **A. Jamieson.** (Inst. Elect. Engin., Journ. 31. pp. 76–89; Discussion, pp. 86–94, Dec., 1901.)—The Liverpool catastrophe proved that a wood strip fastened above the trolley wire is an inefficient guard against springy bronze telephone wires. The Board of Trade and Post Office regulations for guard wires are given. If faithfully carried out, with well-earthed wires, these regulations would give fair security against fallen wires, but the number of guard wires required is great, and their appearance objectionable. Guard wires and their bindings should be made of silicon bronze, instead of the usual galvanised steel: they would then be stronger, would have greater conductivity, and would resist the rapid atmospheric corrosion. The simplest provision for rendering sections of trolley line "dead" is an earthing switch in each car. The usual arrangement of locked switch pillars wastes much time. The only safe and sure plan to prevent dangers from wires falling on to the trolley lines is to place all non-tramway conductors underground, and use no guard wires. Appendices give particulars of tests of trolley and span wires, insulators, &c., supplied for the Glasgow Corporation Tramways.

Discussion.—**M. B. Field** considered that hitherto the telephone and telegraph engineers have used dangerously long spans. If a limit of 120-ft. span were fixed, the risk of breakage would be greatly minimised.

E. H. C.-H.

1002. *Prevention of Accidents on Electric and other Railways.* **S. S. Neff.** (Railroad Gazette, 34. pp. 52–53, Jan. 24, 1902.)—After discussing the various causes of accidents on electric railways, and means for preventing them, the author advocates the use of an automatic device for stopping trains when running past a signal at danger. This has been in use successfully for nearly a year on the Boston Elevated Railway [see Abstract No. 2337 (1900)], and comprises an arm or stop connected by linkwork to the signal, so that when the signal is brought to "danger" the arm will move into the path of a lever on the plug or spindle of an air-brake valve on the "train-pipe" of the car; if now the driver does not see, or neglects, the signal, the stop will strike the lever and move it so as to open the valve and stop the train. The cost of equipping a car is five dollars, and the cost of equipping each signal should not exceed 25 dollars. The paper is illustrated by photographs and drawings.

C. K. F.

1003. *Fenders for Tramcars.* **M. Kosch.** (Elektrotechn. Zeitschr. 23. pp. 84–88, Jan. 30, 1902.)—Fenders are divided into three classes: I. Fenders projecting in front of the car platform. II. Fenders arranged underneath the platform. III. Fenders with springs arranged to shoot forward on the release of a trigger by the motor-man. The merits and demerits of each class are discussed, particularly with reference to their ability to safely take up a person *standing* on the permanent way, or lying with his body in the direction of motion. For these cases no one of the three classes is considered entirely

satisfactory. The fender, of Class I., adopted on the Berlin tramways, is described and illustrated by a sketch. A. E. L.

1004. *Electric Lifts of the City and South London Railway.* (Tram. Rly. World, 11. pp. 13–16, Jan. 9, 1902.)—The article describes fully the construction of the lift cages, the motors and hoisting gear, the switch gear and the safety devices. The efficiency from the motor input to the load hoisted is about 50 per cent. The article contains five illustrations and diagrams. G. H. B.

1005. *Railway Signalling.* **I. A. Timmins.** (Proceedings of Section I. of the International Engineering Congress, Glasgow, pp. 22–32, 1902.)—The author deals with modern developments in the practice of railway signalling. Hydraulic systems are failures. Pneumatic systems are operated on either high or low pressure. The Westinghouse system may be taken as a type of the former, the pneumatic pressure being controlled by electrical means. Both are fully described. Of electrical systems, the earliest were worked by primary batteries, which supplied current to small motors. Such, for instance, was the method of the Union Switch and Signal Company of America. A further development introduced the use of secondary batteries. The first automatic electric system of signalling was fitted by the author on the Liverpool Overhead Railway, the signals being operated by long-pull electromagnets, actuated by the passing train. At the Paris Exhibition an automatic system was fitted, covering two miles of line, similar in general outline to the Liverpool system. The methods of electric signalling adopted at Crewe are finally described. All the systems above mentioned are explained in detail, and all are further illustrated by drawings. It takes considerably less than a second to lower a signal by electricity or to move and lock a pair of points by electromagnets. Pneumatic signals at 500 yards distance take 9 or 10 seconds to complete the return current, and it is not practicable to work signals at 1,200 yards except by electrical means. W. H. S.

1006. *Use of Recording Instruments on Railways.* **C. Jacquin.** (Écl. Électr. 30. pp. 17–28, Jan. 4, and pp. 81–88, Jan. 18, 1902.)—The author gives the results of his experiments with recording apparatus used on the trains of the Paris, Lyons, and Mediterranean Railway, which are lighted electrically. His main object was to discover means by which the vibration of the train might be neutralised, and to ascertain the extent to which this vibration affected the accuracy of the results or the calibration of the instrument. Some instruments by Richard were first used with a dashpot consisting of a rod, 2 mm. in diameter, plunging in glycerine [see Abstract No. 1937 (1901)]. This proved wholly insufficient, the jolting of the train producing a trace of such breadth that nothing could be distinguished. At the end of the rod, therefore, a piston 20 mm. in diameter and 0·5 mm. thick was fixed and made to plunge in a cylinder 25 mm. in diameter filled with glycerine. This blotted out oscillations of every kind, including the variations of voltage which the instrument was intended to register. The piston was therefore pierced with four holes, each of 2 mm. diameter, and a good record was then obtained. A similar result was obtained on diluting the glycerine with water. The instrument was placed in a cupboard in one of the carriages, and suspended by strong rubber bands, which were tightly stretched and fastened to the floor and roof of the carriage. These rubber bands were intended to damp out any very violent oscillation; but unless they were very tightly stretched they were found to be useless. Moreover, the calibration of the

instrument was found to be affected, and this was probably due to the effect of the vibration on the springs actuating the pointer. Some further experiments were carried out with a registering voltmeter by Meylan, which gave good results when properly adjusted. Curves given by the two instruments under the different conditions are reproduced. W. H. S.

1007. *Electrolysis by Earth Returns.* **E. B. Ellicott.** (West. Soc. Engin., Journ. 6. pp. 529–536; Discussion, pp. 536–548, Dec., 1901.)—A general discussion of the question, and a recommendation to obtain a uniform p.d. between rails and pipes (or only a small variation over a given distance), so as to distribute any destruction uniformly, thus making it negligible. Where there is a marked variation of p.d. there is generally a serious disintegration. On that account the Council of Chicago has passed an ordinance requiring that earthed returns should be so constructed that a greater p.d. than 3½ volts should not exist at any point between the water-pipes and rails, and the variation between any two points within 300 ft. should not exceed half a volt.

Discussion.—**McCulloch** pointed out that the current flowing did not depend only on the p.d., but also on the conductivity of the earth at any point, which may vary considerably. Consequently the method suggested is difficult to apply. He described the way in which his Company prepared contour maps to determine the electrical condition of the tramway area. The surest remedy is good bonding and return feeders. Cast welded joints can be guaranteed to have 99 per cent. conductivity of the rail if properly made. **W. E. Foss** gave diagrams showing how the potential of the rail and also of the pipe varies with the distance from the power station in the case of the Metropolitan District (Boston). According to his experience, injury is due chiefly to local favourable conditions, and is most severe at the sharp edges of pipe bells and at a line about 2 ft. on either side of the pipe joint. On account of the rapid variation of p.d. with traffic, there would be difficulty in deciding whether the Council Ordinance is complied with. **Ellicott,** in reply, stated that the conductivity of the earth in Chicago did not vary more than 20 per cent. He described the method of measuring the resistance when a p.d. exists, which consists essentially in allowing an opposing current to flow of such a value that a p.d. is set up equal and opposite to the orginal p.d. [See also Abstract No. 1596 (1900)]. W. R. C.

1008. *Magnetic Field Produced by the Paris Electric Tramways.* **T. Moureaux.** (Annal. Chim. Phys. 25. pp. 139–144, Jan., 1902.)—An account has been given [see Abstract No. 618 (1902)] of the author's investigations at the observatories Parc Saint-Maur and Val-Tayeux. In this paper further comparison is made between the two stations, of which one is, and the other is not, affected by electric tramway working. By suitable damping of the needles the author strives to bring the readings at the two stations more and more into agreement. P. E. S.

1009. *Reduction of Earth-Current Losses on Electric Railways.* **E. Ziehl.** (Elektrotechn. Zeitschr. 23. pp. 145–147, Feb. 20, 1902.)—The author describes a series of experiments made by him, in order to prove that the earth-current losses can be considerably reduced, when either single or polyphase alternating current is used for the working of railways which have the rails as returns. Following G. Kapp's suggestion (see Elektrotechn. Zeitschr. 23. Jan. 2, 1902), the author inserts in the circuit as a "booster" a transformer connected in such a manner that the primary is joined in series to the wire

conducting the current to the motor, and the secondary is connected to the rails. In the author's experiments the assumption was made that the transformer was placed in the middle of the rail, but so arranged that the rail resistance, transformer and earth resistances are put in series. In practice, however, the transformer will have to be put where the potential difference between the rail and earth is zero, or nearly so, and that without the use of the transformer as a booster. The author used in his trials an alternating current of 50 ∿ , and the voltage was kept constant at 215 during the trials. In testing the earth-current losses without the use of the booster, the author found them to be about 10 per cent. of the current passing the rails as return, but with the aid of the transformer arranged as suggested he found the losses to be very considerably reduced, by simply altering the ratio of ampere-turns of the primary and secondary windings of the transformer used. In the experiments made, the best ratio (by which the losses were reduced by about 70 per cent.) was 1·08, the primary winding having 55 turns, and the secondary 51 turns. The author tabulates all the results obtained, and also gives them diagrammatically, by which it is seen that there exists a close relation between the earth current and the current used on the line. The conclusions arrived at by the author are : that in inserting in series a transformer as a booster in the manner indicated, the earth-current losses can be made to be positive, negative, or zero, and therefore the suggestion made by G. Kapp, of introducing single or polyphase transformers as boosters is shown to be a good one, and static transformers are convenient in use, owing to their not requiring much attention. L. G.

ELECTRIC LAMPS AND LIGHTING.

1010. *Glow Lamps on Alternate-current Circuits.* **P. Janet** and **C. Léonard.** (Soc. Int. Élect., Bull. 1. pp. 615–635, Dec., 1901.)—The author in a previous paper deduced formulæ for the above [see Éclairage Élect. 11. p. 507 (1897)] ; from which it appears that for a 100-volt 16-c.p. lamp, at a frequency of 40, the extreme values of the c.p. were 14·1 and 18·5, or 13·7 per cent. from the mean, and the lag 43°·7, reckoning the half-period, since the frequency of this quantity is twice as great as that of the alternating current considered. The results thus obtained theoretically were tested experimentally by M. Léonard. The method employed consisted n measuring the intensity of the light through two diametrically opposite segmental slits in a rotary disc, driven by a bipolar synchronous motor which is supplied with current from the same mains as the incandescent lamp under test, so as to always expose the lamp to the photometer at the moment when the difference of potential has the same value. The slits in the disc are each of a width equal to $\frac{1}{16}$th of the circumference, and the disc is divided into sixteen equal sectors, to enable sixteen values of the intensity to be obtained when there is a single slit. The shaft is provided with a pointer which can be set to any of these sectors. The potential difference and current at the moment of measuring the intensity of the light were determined by Joubert's method. The variations with a 13·7-c.p. (bougie decimale) 110-volt lamp, with a current of frequency 42, were from 12·85 to 15 c.p. The influence of the frequency, of the mass of the filament, and of the form of the curve of differences of potential of the alternating current on the variations in the intensity of the light were also examined. The author also deduces from the curve of intensity of light the variations in the power dissipated by the filament at the same time, and also the variations in the amount of heat-energy stored up in the filament

during the same time. The paper is illustrated by a diagram of connections and curves giving the results of the experiments made. C. K. F.

1011. *Rosemeyer's "Regina" Arc Lamp.* (Elekt. Runds. 19. pp. 84–85, Jan. 15, 1902.)—In this lamp there is a special gas-check, not described, and the carbon-feed is effected by means of a clutch comprising three rings which, when acted upon by the core of the controlling electromagnet, slide on inclined surfaces, and are thus forced together to hold the carbon. The lamp will work at 110 volts with a direct current of 5 amperes. At 100 volts the arc is 7 to 10 mm. long, and the light is emitted throughout an angle of 120°. Tests made by W. Wedding, of Charlottenburg, gave a consumption of current of 1·075 watts per Hefner candle. The lamp burns 160 hours with one set of carbons. The spectrum is very similar to that of sunlight. C. K. F.

REFERENCES.

1012. *The Conservation of Energy from the Engineer's Standpoint.* **Kammérer.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1750–1754, Dec. 7, 1901. Paper read before the seventy-third meeting of the German Naturalists and Physicians at Hamburg.)—Gives examples of energy transformations in engineering cases with the help of load diagrams. W. W. H. G.

1013. *Fault-Finding in Networks.* **P. Charpentier.** (Écl. Électr. 26. pp. 365–370, March 9, 1901.)—The bridge method is used, and applied to complicated networks. The originality of the method consists in making a single measurement to find the fault in a defective section. The method is applicable to a fault between conductors when at least one conductor is not to earth. M. O'G.

1014. *Design of Transformer Substations.* **F. Winawer.** (Zeitschr. Elektrotechn., Wien, 19. pp. 621–624, Dec. 22, 1901.)—The author discusses the design of transformer substations, both underground and above ground, on the Continental kiosk pattern. The safe handling of the switch-gear and convenient arrangement of connections are also discussed. E. K. S.

1015. *Electricity Supply Works Costs in 1899 and 1900.* (Electrician, 48. pp. 410–418, Jan. 3, 1902.)—An article summarising the more interesting results of analyses of electricity supply works published during 1899 and 1900, with curves showing average costs for each of the years 1896–1900. G. W. DE T.

1016. *Transit Problems and Electric Traction on Railways.* **W. Langdon.** (Inst. Elect. Engin., Journ. 31. pp. 253–278; Discussion, pp. 279–281, Feb., 1902. Presidential Address.)—An appendix to the address gives some interesting statistics relative to the present use of electricity for light and power purposes on existing steam railways. G. W. DE T.

1017. *The Incandescent Lamp.* **J. W. Howell.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 923–925, Dec., 1901.)—This paper contains a brief description of the main applications, characteristic features, properties, and methods of using modern incandescent lamps. C. K. F.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JUNE 1902.

GENERAL PHYSICS.

1018. *Gas-Washing Apparatus.* **C. E. Stromeyer.** (Manchester Lit. and Phil. Soc., Mem. 46. 2. pp. 1–3, Feb. 10, 1902.)—In order to gain an increased time of contact between the gas which is under examination and the absorbing liquid, where comparatively large volumes of gas have to be examined, the author devised an arrangement which consists of two bulbs connected by a U-shaped circulating tube for the liquid, and by a spiral, which branches off from this tube below the inlet bulb, at a point below the working level of the liquid, and delivers the bubbles of gas downwards in the centre of the outlet bulb, at a point above the level of the absorbing liquid. The gas invariably breaks into bubbles on entering the spiral, carrying forward a certain quantity of the liquid, which drips from the delivery end at the latter point, on the bubbles emerging and bursting, and returns by the circulating tube. In ordinary bulb apparatus, the time of contact between the gas and the absorbing liquid is limited to what is required by each bubble in rising through about 1 in. of liquid. In this new form, the time of contact does not depend on the depth of liquid, but on the volume of gas passed through the coil per second. A satisfactory specimen of the apparatus had a coil 30 in. long and $\frac{1}{8}$ in. bore, with a difference of level, between the two points, of $1\frac{1}{4}$ in. A stream of air passing at the rate of 7 litres per hour was completely broken into bubbles, the estimated duration of contact being $2\frac{1}{2}$ seconds. A larger model having a coil 4 ft. long and $\frac{1}{4}$ in. bore worked best when about 50 litres per hour were passed through it, giving a period of contact of about 3 seconds. F. J. R.

1019. *Steel Measuring-Tape Apparatus.* **A. E. Burton** and **J. F. Hayford.** (Eng. Record, 45. pp. 80–81, Jan. 25, 1902.)—A brief outline is given of the development of this instrument at the Massachusetts Institute of Technology since 1888, and of the tests to which it was submitted by the U.S. Coast and Geodetic Survey in November, 1900. A 100-m. steel tape, suspended in two catenaries of 50 m., was sometimes applied; this interval is, however, too great in windy weather. With the addition of the thermophone, an improvement introduced by A. E. Burton, which furnishes an instantaneous determination of the actual average temperature of the tape, the instrument is well suited for use even in daylight. H. B.

1020. *Baroscope.* **G. Guglielmo.** (Archives Néerlandaises, 6. pp. 555–562, 1901.)—The author describes various forms of a kind of baroscope. A hollow, but closed sphere of brass, and a solid sphere, of equal weights but unequal volumes, are attached to a balance-beam which, when tilted by the buoyancy of gas lighter than air, will close an electric circuit. In air containing 5 per cent. of CH_4, a sphere of 1 litre capacity would, at ordinary temperature, lose 5 mgrm. of its buoyant force. The same would result, however, if the temperature were to rise by 1° C. or the barometer to sink by 3 mm. To compensate for these effects, the author lets the hollow sphere communicate with the air by a long, narrow tube, or he provides it with a **U**-tube containing a drop of liquid, or he joins a horizontally arranged air thermometer to the beam. Some experiments on the rate of diffusion of illuminating gas through fine tubes are referred to. The apparatus could also be used for demonstrating diffusion, and for other purposes. H. B.

1021. *Small Torsional Oscillations.* **H. Bouasse.** (Journ. de Physique, 1. pp. 21–33, Jan., 1902.)—The author insists strongly on the neglect of experimenters to take account of the mode of variation of torsion with respect to time, and points out the questionable accuracy of the corrections applied in order to eliminate the damping effect of the air. He mentions various sources of experimental error, and points out discrepancies between the results of experiment and theory. Our knowledge of the subject, he says, has increased but very little since the time of Coulomb. [See also Abstract No. 1316 (1899).] W. S.

1022. *Disturbances of a Plumb-bob Suspended on a Steel Wire.* **W. Hallock.** (Amer. Phys. Soc., Bull. 2. pp. 44–45, 1901.) (Abstract.)—During the employment of two plumb-lines, consisting of fifty-pound iron weights, upon steel piano-wire, which were used to establish two points at a depth of over 4,000 ft. in the shaft of a mine, it was noticed that their distance apart was about an inch greater at the bottom than at the top. It is suggested that the divergence might be due to a repulsion of two north magnetic poles formed at the lower ends of the wires by the earth's magnetic field. Observations on iron wires set up by the shaft of the Physical Laboratory of Columbia University confirm the supposition ; repulsion was found to occur all along the line between two parallel vertical iron wires. J. J. S.

1023. *Stress and Strain in an Elastic Solid.* **Kelvin.** (Phil. Mag. 3. pp. 95–97, Jan., 1902.)—The author remarks that the method hitherto followed by writers on elasticity has two disadvantages—(1) that the strain is required to be infinitely small ; (2) that the specifying elements are of two different kinds, viz., simple elongations, *e f g*, and simple shearings, *a b c*. Both faults are avoided if we take for the specifying elements the six edges of a tetrahedron, or the three pairs of face diagonals of a hexahedron.

Cut from the solid a tetrahedon of any shape, A B C D. Let the three non-intersecting pairs of its six edges be denoted by ($f f'$), ($g g'$), ($h h'$). Parallel to A B apply to the faces ADC BDC equal and opposite pulls, uniformly distributed. These two balancing pulls are called a stress component. The same being done for each of the six edges, we have six stress components, P P′, Q Q′, R R′ (2), each parallel to one edge, and these are supposed to be balanced by the mutual forces between the particles of the solid. If $f_0 f_0'$, &c., are the lengths of the specifying elements when the

stress components are zero, the differences between $f_0\, f_0'$, &c., in the case of applied forces, represents the strain. If w be the work done when the stresses are increased from zero to (2), we have—

$$w = \mathrm{P}df + \mathrm{P}'df' + \mathrm{Q}dg + \mathrm{Q}'dg' + \mathrm{R}dh + \mathrm{R}'dh',$$

whence $\frac{dw}{df} = \mathrm{P}\,\frac{dw}{df'} = \mathrm{P}'$, &c. This, he says, completes the molar dynamics of an elastic solid of the most general kind. He proposes to apply the method to the dynamics of a crystal, in a communication promised for the Royal Society of Edinburgh. S. H. B.

1024. *Forced Vibrations and Resonance.* **Rayleigh.** (Phil. Mag. 3. pp. 97–117, Jan., 1902.)—A system being defined by n generalised co-ordinates $\psi_1 \,.\, \psi_2 \,..\, \psi_n$, the general equations of motion are reduced to a series of equations of the form—

$$e_{11}\psi_1 + e_{12}\psi_2 + e_{13}\psi_3 = \Psi_1,$$
$$e_{21}\psi_1 + e_{22}\psi_2 + e_{23}\psi_3 = \Psi_2, \text{ \&c.},$$

where e_{rs} denotes the quadratic operator, $e_{rs} = a_{rs}\frac{d^2}{dt^2} + b_{rs}\frac{d}{dt} + c_{rs}$. The coefficients b refer to dissipation of energy. The forces ψ_1, ψ_2, &c., acting on the system, are then assumed to be of the type—

$$\psi = \mathrm{R}\epsilon^{i(pt+\theta)}$$

The work done by a single force of this type is calculated. The author deals next with a system of one degree of freedom, with the example of an electric circuit closed by a condenser in which acts a force ψ. If a disposable force ψ' be introduced in another part of the circuit, it does a certain amount of work, the negative of which is work withdrawn from the system. The maximum value of this work is found to be $\mathrm{Mod}^2\Psi/8b$. This theory is then extended to two, and subsequently to more degrees of freedom. In the case of two degrees (two electric circuits) the maximum work that can be withdrawn by Ψ_1 from the system subject to a given force ψ_2 is found to be $\mathrm{Mod}^2\psi_2/8b$, and is independent of the constants of the two circuits.

The author then comes to the action of resonators. The effect is as if the disposable force Ψ introduced does no work on the complete value of the corresponding co-ordinate ψ, though it generally does work on the part of ψ due to itself. The author then introduces the theory given by Lamb's paper, "An Electromagnetic Illustration of the Theory of the Selective Absorption of Light by a Gas" [see Abstract No. 1783 (1900)], in which is developed a general law for the maximum energy emitted by a resonator in a uniform medium under the influence of plane incident waves. Lamb finds that the rate at which energy is carried outwards by the scattered waves is $\frac{2n+1}{2\pi}\lambda^2$, in terms of the energy flux of the primary waves, in which λ is the wave-length, and n the order of the spherical harmonic component of the incident waves. The author discusses this result, and thinks that a yet more general theory is involved in it.

Having thus dealt with the energy emitted by a resonator, the author finally considers the energy stored in resonators when the frequencies of the applied forces are nearly the same as the natural frequency of the resonator.

In the case of one degree of freedom ψ, and a force Ψ, he finds for the energy stored $\frac{\pi}{4b}\text{Mod}^2\Psi$, which is independent of a and c. Here a and c are defined by T (kinetic energy) $=\frac{1}{2}a\psi^2$; V (potential energy) $=\frac{1}{2}c\psi^2$. Finally, the case is treated in which the force ψ_2 is of one kind, while ψ, on which resonance depends, is of another. The result here obtained is—

$$\frac{1}{2}c_{11}\int \text{Mod}^2\psi_1 dp = \frac{\pi}{4b_{22}}\text{Mod}^2\Psi_2. \qquad \text{S. H. B.}$$

1025. *Laplace's Capillary Constant.* **G. Bakker.** (Archives Néerlandaises, 6. pp. 758–764, 1901.)—In investigating capillarity we have a choice of two methods, namely, either to consider a system of molecules in motion forming a liquid, or to consider a "homogeneous agent," which produces the same effects in external space as the liquid. In an earlier paper the writer, making use of Van der Waals' theory, proved that the capillary constant satisfies the equation $H = 3\mathfrak{A} - 2B$, where $\mathfrak{A}$ is the work required to separate all the molecules to an infinite distance against their mutual forces, and B is the virial of those forces. In that proof he made use of Euler's integrals. In the present paper he proposes first to prove the same proposition without Euler's integrals, and secondly to give another proof on the hypothesis that the thermic pressure at a given point in the capillary layer is independent of the direction, but without any hypothesis as to the law of force. Any point in the interior of the liquid may be in a homogeneous phase, and for such points $3\mathfrak{A} - 2B = 0$. A point within the capillary layer is not in a homogeneous phase, and the above equation does not apply. The author, then, uses Van der Waals' expression for the potential energy, the law of force being derived from $f\frac{1}{r}\varepsilon^{-qr}$ as force function, and so works out his first proof.

In the second proof he considers a membrane, or lamina of the liquid, in equilibrium under the pressure of its own vapour and two stretched strings at its ends, and if p_1 be the external pressure on an end of the lamina, p_2 the hydrostatic pressure per unit of surface parallel to the surface (*i.e.*, the difference between thermic pressure and cohesion) he obtains the equation

$$H = \int_1^2 (p_1 - p_2)\, dh$$

the indices referring respectively to the interior liquid and the vapour, and h being the direction normal to the surface of the lamina. But if θ denote thermic pressure, and s cohesion, $p_1 - p_2 = s_2 - s_1$, because thermic pressure is assumed to be independent of direction, whence we have—

$$H = \int_1^2 (s_2 - s_1)\, dh$$

By applying Clausius' Virial equation he obtains the result $H = 3\mathfrak{A} - 2B$. [See also Abstracts Nos. 762 and 1475 (1901).] S. H. B.

1026. *Seismometer Indications.* **J. Milne.** (Nature, 65. pp. 202–203, Jan. 2, 1902.)—Modern seismometers indicate the time of arrival of the various earthquake phases. If several instruments are differently installed, however, and at some distance apart, only the commencements and the

pronounced shocks can be identified, while the instruments may differ as to phases and periods. The first tremors of seismograms, the forerunners, are regarded as elastic waves of compression and rarefaction. With regard to the large waves, following after an interval depending upon the distance from the source, both the horizontal bracket instruments and the spring lever seismographs act as indifferent clinographs; we cannot rely upon their horizontal and vertical components, because the ground for a few hundred miles around an epicentre may be thrown into surface-waves. These surface-waves cannot, however, explain the undulating character of seismograms due to earthquakes at very great distances, which seem to actuate horizontal pendulums by horizontal displacements of the ground rather than by tilting. The author, who refers to some clinograph experiments, C. G. Knott, F. Omori, and W. Schlütter all doubt the surface-wave theory. - H. B.

1027. *Seismograph for Strong Earth Tremors.* **G. Agamennone.** (Accad. Lincei, Atti, 11. pp. 116–122, Feb. 2, 1902.)—The author describes, under the name of macroseismometrograph, an arrangement of two horizontal and one large vertical pendulum, for the measurement of earth movements of such intensity as to throw the ordinary instruments out of action. The instrument has been installed at the Rocca di Papa Observatory, after being previously tested on a table to which blows were given, and on a carriage which was run over a mosaic pavement. The seismograms automatically recorded by the pendulums were found to be very satisfactory. While the instrument is in operation, a chronometric arrangement automatically marks the seismogram, so that the time corresponding to any part of the record can be ascertained. D. H. J.

1028. *Turin Seismographic Records in* 1901. **L. Volta.** (Accad. Sci. Torino, Atti, 37. 5a. pp. 127–142, 1901–1902.)—The macroseismometrograph [see preceding Abstract] installed at Turin in one of the towers of the Palazzo Madama, includes a vertical pendulum consisting of a bob of 200 kilos suspended by a steel wire 24 m. long; the author records in some detail many of the daily tracings of this instrument. In general it is to be noted that there is indication in the seismograms, of much more frequent tremors in the NS. line than in the orthogonal direction; whether this is due to a defect in the suspension of the pendulum has yet to be seen. No very strong shocks were manifest during the year; medium shocks (Grade IV. of the Mercalli scale) were recorded on May 25 and October 30; light tremors (Grade II.) on May 3 and June 24; many slight perturbations were shown on the seismograms. D. H. J.

1029. *Earthquake Movements in the Erzgebirge.* **F. de Montessus de Ballore.** (Comptes Rendus, 134. pp. 96–98, Jan. 13, 1902.)—A description of the distribution of the slight earthquake shocks felt periodically throughout this region is given, and the geological causes are explained. There are about 150 epicentres, of which most are concentrated in the south-west of the Erzegebirge, a region very full of metalliferous veins. These epicentres divide into three well-defined groups, the first with centre at Rotham, the second that of Brambach, and the third, embracing the other two, is the seismic ellipse of Vogtlang. There are also some epicentres of less importance along the Elbe. Of the three kinds of geological phenomena of this kind which exist in the Erzgebirge, viz., regions of fracture, lines of least resistance

to volcanic and thermal action, and undulations (*plissements*), only the last has still a considerable action at the present time, and this is shown by the slight tremblings of the earth. J. W. P.

1030. *Transparency and Colour of the Sea.* **J. Thoulet.** (Revue Scientif. 16. pp. 737–741, Dec. 14, 1901.)—The author reviews a book by J. Luksch with the above title, dealing with the observations made by the latter on board the Austrian frigate *Pola* during the years 1890 to 1898 in the Eastern Mediterranean, the Ægean, and the Red Sea. The transparency is estimated by determining the depth to which a disc of sheet iron, painted with lead-white, remains visible; the colour, by comparison with mixtures of solutions of ammoniacal copper sulphate and potassium chromate. Luksch used discs varying in diameter between 36 and 200 cm., and prefers 50 cm. The author prefers, with Secchi, a diameter of 30 cm. The two properties are influenced by the thermometer, wind, altitude of the sun, &c. The transparency is favoured by a blue colour, great salinity and depth of the water, and low temperature; it is least in the summer; for low altitudes of the sun it is in general 33 m. in the Mediterranean, 31 m. in the Ægean, and 21 m. in the Red Sea; the maximum observed was 48 m. Luksch also submerged photographic plates. H. B.

1031. *Climatological Means for Degrees of Latitude.* **W. Bezold.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 53. pp. 1330–1343, Dec. 19, 1901.)—By referring the mean values for solar radiation, air temperature, air pressure, cloudiness, and atmospheric precipitations to the sines of the degrees of latitude, instead of to the latitudes themselves, the author obtains instructive climatological curves, either hemispherical, or, by further taking the arithmetical means between the data concerning the two hemispheres, holospherical. The zone between the parallels of mean barometric maxima covers more than half of the globe, while the belt between the temperature maxima is only 0·3 of the surface. The author gives a simple empirical formula for the connection between solar radiation and mean annual temperature; for latitudes between 20° and 50°, this formula agrees as closely with the means of Spitaler and of Batchelder as those two meteorologists agree with one another. Very interesting are also the solar radiation curves for special days. The total annual radiation is found to be equivalent to 300 thermal days, that is, to 300 times the radiation which a point on the equator receives on March 20. Points situated in the belt between $\pm 37°\ 9'$ lat., which makes up about 0·6 of the surface of the globe, receive more than the mean radiation, points nearer the poles less. The author proposes to designate these degrees of latitude as "mean solar radiation lines." Similarly he speaks of the "mean temperature lines," $+38°\ 18'$ N. lat. and $-35°\ 0{\cdot}5'$ S. lat. H. B.

1032. *Height of the Homogeneous Atmosphere and Mass of the Atmosphere.* **N. Ekholm.** (Öfvers. Kongl. Vet. Akad. Stockholm, Förh. 58. pp. 619–633, Sept. 11, 1901.)—The height H obtained by multiplying the mean height of the mercury barometer by the ratio of the density of mercury to the mean density of air at the level of the sea is termed the *Reduced Height of the Atmosphere.*

The exact height K of the homogeneous atmosphere cannot be calculated, the temperatures of the superior layers of atmosphere being imperfectly known.

Mascart arrived at the result that K differs considerably from H; but the author shows that his reasoning is entirely fallacious, as it would lead to

absurdities such as a negative atmospheric pressure at any height greater than 19 km. The ratio K/H is shown to be 1·0056 by reasoning of the same character as that of Mascart, except that his mean error is avoided. When allowance is made for temperature changes, 1·0024 is obtained as the value of the ratio K/H, the excess of K thus being only 0·24 per cent. of H.

Numerical tables of the pressure, density, and mass of air at different heights are given, and the mass of atmosphere is found to be about 0·000000856 of the total mass of the earth. A. G.

1033. *Atmospheric Pressure.* **G. Guglielmo.** (Accad. Lincei, Atti, 11. pp. 70–77, Jan. 19, 1902.)—Apparatus is described for measuring with a water manometer the amount of pressure which it is neccessary to add or take off in order to bring the volume of a given quantity of air to a value corresponding to a known local mean value of the pressure. A. D.

1034. *Observations at High Altitudes.* **J. M. Bacon.** (Soc. Arts, Journ. 50. pp. 169–174; Discussion, pp. 174–175, Jan. 24, 1902.)—The paper deals with observations from balloons and draws attention to various difficulties. The observer may be entirely ignorant of the fact that he has been drifting with changing air currents. Air streams may follow the windings of an estuary or a mountain ridge below; parachutes are frequently diverted by very slender minor air streams, crossing under various angles and ascending or descending. These minor streams make temperature records very unreliable, and hazes often interfere seriously with light and sound; the air may be more charged with dust at high altitudes than in the large towns below. The discussion by **J. Y. Buchanan, H. R. Mill, W. Marriott** and **W. Reid,** concerned chiefly those minor air streams, the ridge of high pressure between two cyclones, the haze and the transmission of sound in cones analagous to detonation cones of blasting agents in rocks. H. B.

1035. *Russian Rainbow Statistics.* **E. Leyst.** (Soc. Imp. Nat. Moscou, Bull. 1. and 2. pp. 102–184, 1901.)—The author regrets that so little attention is paid to rainbows, and that there is no uniform method for recording them. In European and Asiatic Russia, rainbow records have been kept more or less regularly and reliably, since 1875, at sixty-nine stations, for periods varying between seven and twenty-five years. Having examined 13,332 monthly reports, concerning altogether 4,326 rainbows, the author arrives at the following conclusions: There was a minimum number of rainbows in 1887–8, preceded by a secondary minimum in 1884 and followed by a maximum in 1897–8, with a secondary maximum in 1892–3; the maxima and minima differ by about 80 per cent., the highest average number of rainbows for any station per year being 8·8. Inland stations with summer rains had three times as many rainbows as coast stations; the frequency decreases with dry summers, and probably also with higher elevation. The maximum occurs earliest in the year, in June, in the Caspian districts; latest, in September, on the east coast of Siberia and on the Black Sea. In general the afternoon has twice as many rainbows as the forenoon; the opposite holds for the Caspian and Black Sea districts and sea-coasts in general. Noon rainbows have their maximum frequency in September, evening rainbows in the first days of July. H. B.

1036. *Solar Theory.* **R. Emden.** (Astrophys. Journ. 15. pp. 38–59, Jan., 1902.)—The author elaborates a theory of wave-action for explaining the various phenomena of the sun's surface. He concludes that there will be

produced, at varying depths below the photospheric surface, regions of discontinuity, about which there will be formed unstable wave-fronts similar to the breaking waves we are familiar with. These may give rise to vortex motion, and so lead to the formation of spots, &c. The periodic and localised nature with respect to latitude of these various phenomena appear to admit of explanation on these assumptions. C. P. B.

1037. *Solar Radiation and Earth Temperatures.* **C. G. Knott.** (Roy. Soc. Edinburgh, Proc. 23. pp. 296–311, July, 1901.)—This inquiry was undertaken in consideration of certain observations in the Mediterranean, which indicated that the direct effect of solar radiation was perceptible to a depth of more than 150 feet, as shown by the daily fluctuation of temperature from 8 a.m to 4 p.m. This would mean an accumulation of heat of about 1,460 calories under every square centimetre of the water surface, and the author considers that this cannot be accounted for (at least if Langley's value of the solar constant be adopted) by simple direct solar radiation. To get some definite data on this point, the energy received was calculated by graphic integration, and tables of the resulting values are given. According to this, and using a solar constant of 3, it is found that in the Mediterranean 950 units of heat would be received on Midsummer Day. This reduced to the epoch of the above-mentioned determinations comes to 730 units. An harmonic analysis is then made of the readings of deep thermometers in the Calton Hill at Edinburgh. These show that there is an excess accumulation of 1,200 units during September compared with that during March. The calculated total excess of energy supplied during summer is 100,000 units, so that some 99 per cent. has escaped again by radiation, convection, or conduction. This is in marked contrast to the result obtained from the ocean determinations, and it is hoped more observations will be made in widely separated regions to elucidate the matter. C. P. B.

1038. *Effective Temperature of the Sun.* **W. E. Wilson.** (Roy. Soc., Proc. 69. pp. 312–320, Jan. 31, 1902.)—The author has repeated his experiments of 1894 with a different radiator for the comparison source of temperature. In the former case a strip of platinum heated by electric means was employed in one arm of the radio-micrometer. This has been replaced by a long porcelain tube, 2 ft. in length and 1 in. diameter, heated to any desired degree in a gas furnace. The radiation from the interior of such a cavity appears to more nearly fulfil the conditions of a perfect radiator. The solar comparison was made as before, using the reflected light from the unsilvered glass plane mirror of the heliostat. The mean effective temperature, using Rosetti's determination of the amount of terrestrial atmospheric absorption, is 5,773° C. If the total loss due to absorption in the sun's own atmosphere be also considered, the value of the temperature would be near 6,590° C. C. P. B.

1039. *Origin of Double Lines in the Spectrum of the Chromosphere.* **W. H. Julius.** (Astrophys. Journ. 15. pp. 28–37, Jan., 1902.)—On the theory previously put forward by the author that the chromospheric light is to a large extent composed of the light from the photosphere which has undergone anomalous dispersion in the absorbing vapours of the sun, it is evident that the wave-lengths of the bright lines of the prominences, chromosphere and flash, cannot be the same as the wave-lengths of the corresponding absorption lines in the ordinary spectrum. Each bright line corresponding to an absorption line of wave-length λ is supposed to be produced by radiations of wave-length $\lambda \pm \delta$. If curves be drawn for the light distribution in a

chromospheric line on this hypothesis it will be found that the lines should be double. The author has found, on examining the photographs taken by the Dutch Expedition during the eclipse of May 18, 1901, that the chromospheric lines are double ; on one plate taken just after third contact, all the lines (150) are double between $\lambda = 3{,}889$ and $\lambda = 4{,}600$. At the same time it must not be forgotten that the chromosphere forms a source of radiations in itself, and it is a question what is the relation between the emitted chromospheric light and the abnormally refracted photospheric light.

E. C. C. B.

1040. *Ultra-Neptunian Planet.* **G. Forbes.** (Roy. Soc. Edinburgh, Proc. 23. pp. 370–374, July, 1901.)—Additional confirmatory data are supplied concerning the probable existence of a planet having an orbit exterior to that of Neptune. The view first announced in 1880 was based on the determination of the Aphelia of seven comets. These have been revised, and new orbits considered, especially of the comet of 1556. The extent of the perturbations produced is so great that the mass of the supposed planet would be greater than that of Jupiter. C. P. B.

REFERENCES.

1041. *The Harmonic Analyser.* **L. Grabowski.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 717–889, July, 1901.)—In this paper the author describes the extremely convenient instrument designed by O. Henrici and constructed by Coradi, of Zurich. The theory and use of the instrument are fully discussed, with the corrections to be applied in its practical employment. G. W. DE T.

1042. *Measurement of Sunshine.* **C. F. Marvin.** (Monthly Weather Rev. 29 pp. 454–458, Oct., 1901.)—The general principles of sunshine registration are described, special attention being drawn to the incomplete record of the black-bulb thermometer. The remainder of the paper deals with the new Angström electric compensation pyrheliometers which are to be used in the meteorological investigations of the Weather Bureau. C. P. B.

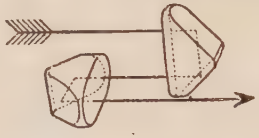
1043. *Sun-spot Period and the Meteorology of Jamaica.* **M. Hall.** (Monthly Weather Rev. 29. pp. 503–504, Nov., 1901.)—Comparisons are given of the mean daily temperature, rainfall, and spotted area of the sun's surface from 1867 to 1897, and curves plotted showing suggestive coincidences among the three phenomena. C. P. B.

1044. *Photographs of the Corona, May 28, 1900.* **T. Heath.** (Roy. Soc. Edinburgh, Proc. 23. pp. 396–400, Dec., 1901.)—The paper contains descriptions of four photographs of the corona obtained at Santa Pola, on the east coast of Spain, during the total solar eclipse of May 28, 1900. The instrument employed was a Cooke triple objective of 6 in. aperture and 104 in. focal length mounted equatorially. Reproductions from the four photographs accompany the paper, and also a drawing showing the details found in all the negatives. C. P. B.

1045. *New Star in Perseus.* **R. Copeland.** (Roy. Soc. Edinburgh, Proc. 23. pp. 365–369, July, 1901.)—The paper contains brief notes on the first observations made on the new star at the Royal Observatory, Edinburgh, with a sketch of the spectrum seen. C. P. B.

LIGHT.

1046. *Porro Prism Field-Glass.* **W. R. Warner.** (Amer. Soc. Mech. Engin., Trans. 23. No. 926. pp. 313–324; Discussion, pp. 324–326, Dec., 1901.)—A clear account in popular language of this modern form of field-glass, in which the clear definition and large field of the astronomical telescope are obtained without its inconvenient length, by making the rays traverse the tube three times by means of reflecting prisms. The image is also rendered erect by the series of reflections. The idea is due to Porro, an engineer to whom a patent was granted by Napoleon III. about fifty years ago, but the glasses of the day were too imperfect for the purpose. The credit of first applying the principle belongs to Professor Abbe, of Jena. In his instrument, known as the Zeiss, the prisms are made of one of the new Jena glasses, a



boro-silicate crown, and only absorb 4 per cent. of the light. The pupillary distance can be adjusted. An American model was brought out by Warner & Swasey two years ago, and the design has been freely copied by other manufacturers. While the magnifying power of the old Galilean type field-glasses was 4 or 5 diameters, that of the new, but a fraction of their size, is 6–10, with much more extensive field. It has been alleged that placing the objectives an inch wider apart than the eyes imparts a stereoscopic effect. The author has investigated this claim by means of a special instrument with movable objectives, and declares it to be untenable, observers having been misled by the improvement in definition. A. E.

1047. *Modern Lighthouse Lamps.* **J. A. Purves.** (Feilden, 6. pp. 121–128, Feb., 1902.)—The multiplication of lighthouses round our coasts has required a multiplication of distinctive signals without, at the same time, decreasing the power of the beam emitted. A description is given, with illustrations, of recent developments in systematic signalling apparatus. Bourdelle's mercury trough, introduced in 1890, allowed rapid revolution and the employment of beams of greater power, the so-called *feux éclairs.* A spindle eclipser designed by the writer is described. It consists of a dioptric panel 180° in azimuth and altitude, a dioptric mirror occupying the other 180° of azimuth. A good oil lamp is placed at the focus and the apparatus can revolve. Any group-flashing signal is then obtained by a suitable design of eclipser.
G. E. A

1048. *Carmen Opaque Projector.* (West. Electn. 30. p. 125, Feb. 22, 1902.)—An optical instrument adapted for projecting the image of any object up to a size of 12 in. by 14 in. by 2 in., whether opaque or transparent. The object is clamped to a shelf, strongly illuminated by two arc lamps of 700 c.p. each, and an image formed with a magnification of 10 diameters. G. E. A.

1049. *Reflecting Power of Metals for Infra-red Rays.* **E. Hagen** and **H. Rubens.** (Zeitschr. Instrumentenk. 22. pp. 12-54, Feb., 1902. Communicated by the Physikalisch-Technischen Reichsanstalt.)—A former paper [see Abstract No. 452 (1902)] is repeated, with the addition of some more tables. The method is then extended to measure reflecting power for infra-red rays. The application of the comparative method employed is shown to be allowable since the achromatism of the projecting system of quartz-fluor-spar is found to be sufficiently perfect between the limits 186 $\mu\mu$ and 1,500 $\mu\mu$. A Nernst glowing strip was substituted for the arc lamp. Improved values are given for the reflecting powers of old silver, steel, and copper, and the following powers are given in percentages of the incident radiation :—

For λ =	700	800	∞	1,000	1,200	1,500 $\mu\mu$
Freshly cleaned silver	94·6	96·3	—	96·6	—	98·4
Old silver	—	91·6	—	94·4	97·1	98·5
Platinum	69·0	70·3	73·6	75·5	77·7	79·0
Nickel	68·8	69·6	71·6	73·5	76·5	81·4
Steel (unhardened)	57·6	58·0	—	62·3	67·8	71·9
Gold	92·3	94·9	96·4	97·1	97·6	97·3
Copper (purest commercial)	83·4	88·6	91·6	93·0	95·1	94·5
Rosse's alloy	66·8	71·5	74·1	74·6	75·4	76·5
Schroeder's alloy No. 1	67·2	71·5	73·2	74·9	76·1	76·5
Schroeder's alloy No. 6	69·4	74·5	7·49	76·0	76·1	77·0
Mach's magnalium	83·3	84·3	—	84·1	—	83·6
Brandes-Schünemann alloy	54·9	63·1	—	71·3	—	80·9

The table from which the above is taken contains all the values found for these metals from 251 $\mu\mu$ to 1,500 $\mu\mu$, and for electrolytic copper from 450 $\mu\mu$ to 700 $\mu\mu$. Reflection is much more uniform for infra-red than for visible and ultra-violet rays. G. E. A.

1050. *Reflection Fringes Formed by Silvered Surfaces.* **M. Hamy.** (Comptes Rendus, 134. pp. 443–446, Feb. 17, 1902.)—Two silvered glass surfaces, very truly plane, are capable of being rendered very truly parallel by means of a special contrivance. One surface is fully silvered, the other surface, N, facing it, is thinly silvered, and forms the plane side of a plano-convex lens, whose remote focus is F. Two kinds of fringes are obtained by reflection, which are stated to be very bright, and suitable for the separation of close radiations even when faint. To obtain those of the first kind the reflecting surfaces are placed at a small angle, and the incident light passes through one-half of a circle described about the point F, with radius less than that of the pupil. They are observed without an eyepiece by placing the eye opposite the other half of the circle. In the case of the second kind of fringes, the light is reflected towards the lens by means of a totally reflecting prism placed at the focus F. When the light fills the faces containing the right angle, the fringes may be seen, localised in the focal plane, in the image of the prism formed by auto-collimation. They assume the form of arcs of circles, with F as centre. The appearance varies with the reflecting power of N. When this is about 0·8 the maxima are very spread out, and the minima are exceedingly fine dark lines. A. E.

1051. *Effect of Refraction on Observations with Vacuum Tubes.* **E. Goldstein.** (Deutsch. Phys. Gesell., Verh. 4. 2. pp. 4–12, Jan. 24, 1902.)—Attention

is drawn to the fact, that if the gaseous particles in a tube are rendered luminous, the interior of the tube is seen illuminated, but if the inside wall of the glass becomes luminous, *e.g.*, by phosphorescence, the light appears to come from the outer surface of the glass. E. Wiedemann found (1880) that the outside was luminous in wide tubes and the inside in narrow ones. It is asserted that illumination of the interior wall is, within limits, always accompanied by the appearance of light on the outside of the glass. This appearance is shown to be an optical illusion depending on total reflection and on the relation between internal diameter of tube and thickness of glass. It exists so long as the thickness is equal to or less than half the internal radius, and observations with tubes in which this relation had different values verified this calculation. Also the light (blue, red, &c.) from phosphorescent material affixed to the interior of the tube appeared to come from the outer surface. Canal rays can thus be distinguished from ordinary kathode rays since the gold-yellow light due to the former proceeds from the inner side of the glass, while the light from kathode rays appears to come from the outer surface.

G. E. A.

1052. *Refractive Index of Liquids at Low Temperatures.* **G. Kučera** and **C. Forch.** (Phys. Zeitschr. 3. pp. 132–134, Jan. 1, 1902.)—It has already been shown that the dielectric constant of a liquid decreases with the temperature, in such a way that at the temperature of liquid air Maxwell's law connecting it with the refractive index is very approximately obeyed for all substances hitherto investigated, the substance at that temperature being, of course, a solid. The manner in which this decrease takes place is, however, very different for different substances, some showing first a maximum before the decrease occurs, *e.g.*, CS_2. Alcohols, on the other hand, show a continuous decrease. It therefore becomes interesting to study the temperature variation of the refractive index. The liquid is enclosed in a prism whose refracting edge is horizontal ; by this means the surface layer of the substance under examination forms one face of the prism. It is then enclosed in a freezing mixture, solid CO_2 and ether, and its refractive index measured by a total reflexion method. While the spectrometer is being set, another observer takes the temperature by means of a platinum thermometer. The results show that the refractive index, n, may be calculated from formulæ of the form $n = a + bt + ct^2$, where for alcohols a varies between 1·34 — 1·42 and b from 0·00046 — 0·000596. For CS_2—$n = 1{\cdot}64362 - 0{\cdot}000733t + 0{\cdot}000009t^2$.

R. S. W.

1053. *Nature of White Light.* **M. Planck.** (Ann. d. Physik, 7. 2. pp. 390–400, Feb., 1902.)—The author considers that the two apparently contradictory views of Gouy and Carvallo [see Abstract No. 2085 (1901)] may not be fundamentally incompatible. It is unprofitable to begin by examining the source of light, since whatever differences may exist in the individual oscillators are removed by mutual absorption and internal reflection. Further, the energy of a single partial or sine vibration is, like that of a single gas molecule, too small to be perceived alone. An unjustified assumption is made if it is considered that the mutual effect of partials of sufficiently near frequency would be to cause visible interference phenomena. The necessary part is not the existence of interference of partials but the regularity of it. The interference of two rays in the same pencil is then treated mathematically, and the results are summed up as follows : Normal white light of constant intensity is completely defined (1) by the energy distribution in the various

parts of the spectrum, (2) by the law that, within a small part of the spectrum in which the energy distribution may be considered uniform, the energies and phase constants of the single simple periodic partials into which the light vector can be broken up are absolutely irregular. If the second law is applied directly to the whole spectrum, the laws of probability give a quite definite distribution as the most probable, and this is the distribution actually found by Paschen, Lummer, and others. [See also Abstract No. 1250 (1900).]

G. E. A.

1054. *Curvature of Retinal Images, taking into Account the Laminated Structure of the Crystalline Lens.* **A. Gleichen.** (Deutsch. Phys. Gesell., Verh. 4. 2. pp. 13–24, Jan. 24, 1902.)—The author adopts for the lens the law of index found by Matthiessen, of Rostock [see "Beiträge zur Dioptrik der Krystallinse," Wiesbaden, 4 Folgen.], and expresses regret that Matthiessen's valuable labours have met with so little recognition. If y be the distance of a point P on the axis of the lens from the kernel, b the value of y at the surface, we have $n = \alpha - \beta(y/b)^2$, where $\alpha = 1{\cdot}4100$ and $\beta = 0{\cdot}0350$. The radius of curvature r of the lamina through P varies as y. In the investigation of the curvature of the image, the object is assumed to be a surface of revolution about the optic axis, and the calculations are based on Petzval's theorem published in 1843. If we have a system of lenses in contact, and the object be a plane at right-angles to the axis, the radius of curvature R′ at the vertex of the image is given by $\frac{1}{R'} = \Sigma \frac{1}{n_k f_k}$, where $\frac{1}{f_k} = (n_k - 1)\left(\frac{1}{r_k} - \frac{1}{r_{k+1}}\right)$, r_k, r_{k+1} being the radii of the surfaces of the kth lens. A portion of the paper is occupied by a historical discussion of this theorem, which is nearly satisfied by most anastigmatic photographic objectives. It applies in all cases where the aperture of the diaphragm is far from being a point, as in the eye, the diameter of the pupil varying from 5 mm. to 8 mm. The author obtains the following formula from his calculations :—

$$\frac{1}{R} - \frac{1}{n_0 R'} = \frac{1}{r_0}\left(1 - \frac{1}{n_0}\right) + \left(\frac{1}{r_1'} - \frac{1}{r_1}\right)\left(\frac{1}{n_1} - \frac{1}{n_0} + K\right)$$

R, R′ being the radii of curvature of object and image, r_0 the radius of the cornea, r_1 and r_1' the radii of the anterior and posterior surfaces of the lens, n_0 the index of the vitreous humour, n_1 of the outermost coat of the lens, and K a constant depending only on α and β above. Mathiessen gives the value 1·3750 for n_1, and according to Helmholtz $r_1 = 10$ mm., $r_1' = -6$ mm. when the eye is accommodated for distant vision, and $r_1 = 5$ mm., $r_1' = -5$ mm. for near vision. These values give $\frac{1}{R} - \frac{1}{1{\cdot}335 R'} = 0{\cdot}0475$ for distant vision, and 0·0576 for near vision. If the object be plane, *i.e.*, $R = \infty$, then we get $R' = -15{\cdot}7$ mm. for distant and $-13{\cdot}0$ for near vision. Thus the image is not plane, but has nearly the curvature of the retina, though the difference of radius, 2·7 mm. for near and distant vision, seems large. Further, straight lines in the object system give, not straight lines, but circular arcs in the image system. The author remarks that our knowledge as to the process of accommodation is incomplete. Nagel [see "Handbuch der gesammten Augenheilkunde," Graefe & Saemisch, pp. 461, 472] has found that there is an increase of pressure at the back of the eyeball and a relaxation at the front. Possibly this may cause slight increase in curvature of the retina as the object regarded approaches nearer.

A. E.

1055. *The Michelson-Morley Experiment.* **W. M. Hicks.** (Phil. Mag. 8. pp. 9–42, Jan., 1902.)—In this paper the author considers in detail the theory of this experiment, which is complicated by the changes produced by actual reflection at a moving surface. The correction due to alteration in the angle of reflection was pointed out by Lorentz, and allowed for in the case of the joint experiment. Reflection, however, also produces a change of wave-length, and the angle of incidence varies by a small quantity of the first order as the direction of drift of the apparatus changes. These corrections are made in the present paper. As it did not appear legitimate to assume beforehand that the ratio of the velocity of the earth through the ether to that of light is extremely small, the general theory is worked out without approximation, and is found to be comparatively simple. The principal result of the correction is that the effect to be expected is the reverse of what had hitherto been supposed. An examination of Michelson and Morley's numerical results in the light of the complete theory leads to the important result that, in place of giving a null result, there is distinct evidence of an effect of the kind to be expected. The suggestion of G. F. Fitzgerald, put forward to explain the supposed null result, that the motion of a solid through the ether produces a small extension perpendicular to the direction of drift, and a contraction in this direction, is required by the theories of Lorentz and of Lummer as to the relations between matter and ether. In the light of the present complete theory, this contraction would increase instead of annulling the displacement to be observed. The author finally shows that a suitable modification of the experiment will enable the question of the existence of such a contraction to be determined, and if it exists, will make it possible to measure it. G. W. DE T.

1056. *Theory of Fluorescence.* **W. Voigt.** (Archives Néerlandaises, 6. pp. 352–366, 1901.)—The formulation of a complete theory of fluorescence and phosphorescence on the basis of the electron hypothesis is at present impossible, owing to our want of knowledge of the internal constitution of molecules. All that is possible at present is, by the aid of known experimental results, to obtain certain generalisations of the ordinary dispersion equations of the electron theory. The author considers that the experimental evidence warrants the conclusion that these phenomena are due to irregular vibrations arising as a consequence of, but not directly excited by, the incident light. The free negative electrons would be greatly more susceptible to such excitation than the far more massive ponderable portions of the molecules, which, on the electron theory, are associated with the positive electrons. It might be assumed, therefore, that the latter are indirectly set in vibration by the action of the former. Another hypothesis, which the author considers as being, on the whole, more in accordance with the observed phenomena, is that the molecules of a fluorescent substance are capable of existing in two or more distinct states, to which correspond distinct intrinsic periods of the electrons.

The passage from one state to another is assumed to be conditioned (as in the case of a partly dissociated gas) by purely molecular circumstances. In such a medium, if there is sensibly less damping in the state corresponding to the longer period of the electrons, there will in this state be sensible fluorescence, and in the other sensible absorption. The paper concludes with an investigation, on this hypothesis, of the dispersion equations in the case of crystals with three mutually perpendicular axes. G. W. DE T.

1057. *Photographic Apparatus for Analysis of Lightning.* **B. Walter.** (Phys. Zeitschr. 3. pp. 168–171; Discussion, pp. 171–172, Jan. 15, 1902. Paper read before the 73rd Naturforscherversammlung at Hamburg, Sept. 26, 1901.)—A brief discussion of the conditions to be fulfilled by the apparatus used. R. S. W.

1058. *Asymmetry of Zeeman Effect.* **G. W. Walker.** (Phil. Mag. 3. pp. 247–251, Feb., 1902.)—An investigation is given accounting for asymmetry as a second order term arising from the magnetic field. The theory requires that the component towards the violet should have the greater displacement, in this respect agreeing with Voigt's theory, but it differs from Voigt's theory in that it requires the asymmetry to increase with the strength of the magnetic field. According to both theories, too, the actual difference of displacement, other things being equal, is greater at the red end of the spectrum; but the asymmetry is a greater fraction of the separation at the violet end, according to Voigt, at the red end according to the present theory. It might also account for certain lines not being resolvable, but slightly shifted towards the violet. W. E. T.

1059. *Errors in Ruling Diffraction Gratings.* **H. S. Allen.** (Phil. Mag. 3. pp. 92–95, Jan., 1902. Paper read before Section A of the British Association, Sept. 17, 1901.)—Errors made in the ruling of a grating cause the appearance of bands, which are seen by focussing the telescope nearly on the surface of the grating. Two cases are considered in which images are formed by a grating, the two halves of which are ruled to different pitches. Two overlapping beams are thus produced which form focal bands. In the gratings examined the principal error was periodic. A change in the bands from bright to dark, as the telescope is focussed in or out, depends on the sequence of the wide and narrow rulings. G. E. A.

1060. *The Use of Stationary Capillary Waves as Diffraction Gratings, and the Surface Tensions of Water and Mercury.* **A. Kalähne.** (Ann. d. Physik, 7. 2. pp. 440–476, Feb., 1902.)—The velocity of waves on the surface of a liquid is given by the equation, due to Kelvin, $v^2 = \frac{g\lambda}{2\pi} + \frac{2\pi\alpha}{\lambda\sigma}$, α denoting the surface tension, and σ the specific gravity. Transposing, and writing $n\lambda$ for v, we get $\alpha = \lambda^3 n^2\sigma/2\pi - g\lambda^3\sigma/4\pi^2$. When λ lies below a certain value, the second term is small compared to the first [owing to the largeness of n^2], and in this case the wave-length depends mainly on the surface tension. It is with these short waves, designated capillary by Kelvin, that the paper deals. The stationary waves are obtained by allowing two needles in connection with an electrically driven tuning-fork to dip into the liquid. By utilising this stationary system as a reflection grating, the wave-length, *i.e.*, grating interval, can be determined with great accuracy. Then, λ and n being known, the surface tension is obtained from the above formula. In the case of water at 18° C., in contact with moist air, the author finds $\alpha_{18} = 73{\cdot}77$ dyne/cm. For mercury, the surface tension was found not to be constant, but to diminish with time—a result in accordance with well-known experiments. The highest value obtained by the author was 432 dyne/cm. at 18° C.

In performing the experiments, a sodium flame served as source, the rays falling at an incidence of about 80° on the middle part of the wave-system. As the grating interval was large, about 1 mm., the diffraction angle for the 1st order spectrum was only 10′, and refined apparatus was therefore necessary to

obtain an accuracy of 1 in 1,000. A very good goniometer was used, the axis of which could be placed vertically. The frequency of the tuning-fork was 510. The corrections due to the fact that the lines of the grating are not straight, but portions of confocal hyperboles, and to various other sources of error are discussed at length. A. E.

1061. *Spectra of Interference Bands.* **A. Cornu.** (Archives Néerlandaises, 6. pp. 593–606, 1901.)—The difficulty, noted by Fresnel, of distinguishing the central white fringe is explained, starting from a previous conclusion (Comptes Rendus, 1881) that in a system of interference bands produced by means of a heterogeneous light having a continuous spectrum, there always exists an achromatic fringe which takes the place of the central fringe, and which is found at that part of the field where the most intense radiations present a maximum or minimum phase difference. The bands are observed in a spectroscope with the slit normal to the direction of the bands. The case is analysed in which two parts of a ray traverse equal thicknesses, e, of two media, pass normally through two slits $2a$ cm. apart and form bands. The phase difference is then $\phi = y(2ax/D + \alpha + \beta y)$, where y is $1/\lambda$, x the lateral displacement of the band, D its distance from plane of slits, and α and β are constants equal to ea and eb respectively. The two media have a difference of refractive index expressed by $n' - n'' = a + by + cy^2$. The first equation represents a family of hyperbolæ with common centre and asymptotes. Now if a spectroscope were made in which the deviation could be expressed by $u = u_0 + hy$, u_0 and h being constants, the sheaves of bands seen under above conditions would be hyperbolæ, and the value of y could be found from $y = (u - u_0)/h$, h being the distance of the fringe along the slit. The hyperbolæ have a horizontal asymptote and an oblique one, the latter being formed by a straight bright band. There is also an achromatic band corresponding to $\partial\phi/\partial y = 0$. The tangent which touches the hyperbola $\phi = \mu$ determines the achromatic, or apparently central, fringe. The point where the y axis is cut by the oblique asymptote is called the characteristic point, its distance from the origin being $y_0 = -\frac{a}{b}$. It is deduced that when the characteristic point is on the negative side of y, a and b have the same sign, and the achromatic fringe is further from the origin than the fringe of no phase difference, and the apparent displacement of the central fringe is greater than the displacement calculated from $\phi = 0$ (case of quartz cut parallel to axis). When the characteristic point is at infinity, observation agrees with calculation (gypsum cut in cleavage planes). If the characteristic point is on the positive side of y, the apparent observed displacement is less than the calculated one (topaz cut along cleavage planes). When the characteristic point coincides with the origin, the law of dispersion reduces to $n' - n'' = by$. This holds when the fringes are obtained by means of a biquartz, when the calculated displacement is half the observed. To verify the above theory a spectroscope was made in which (1) the prism is composed of two prisms of crown and one of flint glass ; (2) the collimator slit is slightly curved to make the spectrum rays straight all over the field ; (3) the objectives of the collimator and telescope are replaced by concave mirrors to avoid deformations due to imperfect achromatism ; (4) observations are made photographically with plates made orthochromatic by an erythrosine bath. With this apparatus, using two plates of topaz, the displacements, for yellow light, of the apparently central band and that corresponding to $\phi = 0$ were 35 and 44 bands respectively, these numbers agreeing with Fresnel's. G. E. A.

1062. *Radiation from Mixtures of Chlorides of Radium and Barium.* **T. Tommasina.** (Comptes Rendus, 133. pp. 1299–1301, Dec. 30, 1901.)—The author here proves that such radiations experience reflection. A concave parabolic mirror of silvered copper was employed in conjunction with a Curie electroscope. The salts were contained in a small tube placed at the focus of the mirror and distant 65 cm. from the upper disc of the electroscope. The mirror had a focal distance of 25 mm. and an aperture of 12 cm. The radiation being thus directed upon the electroscope, readings of the leakage were taken at intervals of a minute with the mirror present and absent. In the former case the rate of leakage is about double, showing the action of reflected rays. A further contrivance by which the action of secondary radiations from the mirror surface is eliminated is described, and thus the action is reduced to one of pure reflection. J. W. P.

1063. *Transmission of Excited Radio-activity.* **E. Rutherford.** (Amer. Phys. Soc., Bull. 2. pp. 37–43, 1901.) (Abstract.)—The excited radio-activity produced by thorium compounds is intimately connected with the power of giving off a radio-active emanation. The emanations from thorium and radium behave like radio-active gases or vapours. They diffuse rapidly through gases, through porous substances like cardboard, and, unlike the gaseous ions which they produce in their path, pass through plugs of cotton-wool and bubble through solutions with no absorption. The author considers that these emanations are in some way the direct cause of excited radio-activity. The following facts support this view: (1) Only the substances which emit emanations have the power of exciting radio-activity. (2) If the emanating power of thoria or radium is partly destroyed by strongly heating, the power of exciting radio-activity diminishes in like ratio. (3) Excited radio-activity can be produced in substances if the emanation and not the radio-active substance is present. On the other hand, the power of exciting radio-activity by the radio-active substance itself is very greatly diminished by a current of gas passed over it, which carries away the emanation. The characteristic property of excited radio-activity is that it can be confined to the kathode in a strong electric field. It is probable, therefore, that the radio-activity is due to the transport, in the electric field, of positively charged carriers of some kind. The experiments described support this view, and show that the carriers travel in an electric field with about the same velocity as the positive ion. The method employed to determine the velocity of the carrier is a modification of one already used in a determination of the velocity of the negative ion produced at the surface of a metal by ultra-violet light. It depended on the use of an alternating electric field. A direct p.d. was commuted by means of a revolving commutator into an alternating p.d. of known frequency. If such an alternating field is applied to two parallel plates between which a radio-active emanation is kept uniformly distributed, equal amounts of excited radio-activity are produced in each electrode. If, in series with an alternating p.d. $= E_0$, a battery is placed of e.m.f. E, less than E_0, the positive carrier moves in a stronger electric field in one half alternation than in the other. A carrier consequently moves over unequal distances during the two half alternations, since the velocity of the carrier is proportional to the strength of the electric field in which it moves. Thus the excited radio-activity will be unequally distributed over the two electrodes. If the frequency of alternation is sufficiently great only the positive carriers within a certain small distance of one plate can be conveyed to it, and the rest, in the course of several succeeding alternations, are carried to the other plate.

Assuming that the carriers are produced at a uniform rate at each point between the plates, and that no carriers disappear by recombination, it can be shown that the velocity of the carrier is given by the equation :—

$$K = \frac{2(E_0 + E_1)}{E_0(E_0 - E_1)} \cdot \frac{d^2}{T} \cdot \rho,$$

where d = distance between the parallel plates ; T = time of a half alternation ; ρ = ratio of the excited radio-activity on the plate which has less, to the sum of the radio-activity on both plates. In the experiments the values of E_0, E_1, d, and T were varied, and the general results were in agreement with the equation. For experiments on thoria emanation a thick layer of thoria was placed in a shallow copper vessel inside an ebonite box, 11 cm. square and 3 cm. deep, which was tightly waxed down to a metal base. The thoria was completely covered with two layers of filter-paper, which cut off most of the direct radiation, but readily allowed the emanation to pass through. The apparatus was rendered air-tight by a metal lid dipping into a mercury trough round the top of the ebonite box. At the beginning of an experiment a square sheet of aluminium-foil was placed over the paper covering the thoria, a zinc plate on top of the ebonite box, and the lid placed in position. This was done as quickly as possible, and the alternating electric field was then applied. The emanation rapidly diffused through the paper and thin aluminium-foil, and distributed itself between the plates in the electric field. After an interval, varying in the experiments from 20 to 90 minutes, the aluminium and zinc were removed, and their radio-activity tested in the usual way by a delicate quadrant electrometer. The ratio of the excited radio-activity on the two exposed plates was thus determined. This ratio was found to be independent of the time the plates were left before testing, as the radio-activity on each plate decays at the same rate. The values found for K, expressed in cms. per second for a potential gradient of 1 volt per cm., varied with different voltages and distances between the plates from 1·17 to 1·7. Temperature 18° C. Air fairly dry.

It appears as if the value of the velocity of the positive carrier of excited radio-activity is the same or not very different from the velocity of the positive ion produced in gases by Röntgen or Becquerel rays. In a recent determination Zeleny (Phil. Trans. Roy. Soc. 1900) found the velocity of the positive ion to be 1·36 cm. per second for a potential gradient of 1 volt per cm. at atmospheric pressure and temperature. [See also Abstract No. 2420 (1900).] J. J. S.

1064. *Radio-activity of Thorium.* **K. A. Hofmann** and **F. Zerban.** (Chem. News, 85. pp. 100–101, Feb. 28, 1902. From Berichte Deutsch. Chem. Gesell. Feb., 1902. Communication from the Chemical Laboratory of the Royal Academy of Science at Münich.)—It was found that thorium oxide, obtained from the minerals bröggerite, clèveite, and samarskite, which at first was strongly radio-active, lost its activity after being kept for some months. This appears to indicate that thorium oxide possesses only an induced radio-activity. The authors suppose that the thorium which they prepared acquired its activity from uranium, which is always present in the minerals used. They found that thorium preparations from a Brazilian monazite sand free from uranium were quite inactive immediately after their separation. Moreover, inactive thorium ore thus obtained became strongly radio-active after it had been left for a long time in contact with feebly active uranium. Thorium

obtained from minerals containing a large proportion of uranium was found to be strongly active ; that got from various minerals with a small percentage of uranium was feebly radio-active. J. J. S.

1065. *Radio-active Lead.* **F. Giesel** (Chem. News, 85. pp. 89–90, Feb. 21, 1902. Berichte Deutsch. Chem. Gesell., Jan. 18, 1902.)—Giesel prepared 3 mgr. of an intensely radio-active substance from 2,000 kg. of uranium ore. It behaved like lead and also exhibited strong radiation a year after. Demarçay found that the HCl solution of this substance gave a spectrum showing that lead was the predominating element, and that traces of Ca, Ba, Sr, Cr, Al, Mn, Bi, and Sn were present, besides Mg and Fe in particular. Two very weak lines, λ3659·6 and λ4116·8, were not identified, and the radium lines were totally absent. The lines are therefore due either to a new substance or to lead made radio-active by radium. A number of reasons are given to show that Hofmann and Strauss's claim to have discovered a radio-active body closely allied to lead is not upheld by their experimental work. [See also Abstract No. 1889 (1901).] G. E. A.

1066. *Conductivity produced in Dielectric Liquids by the Rays from Radium.* **P. Curie.** (Comptes Rendus, 134. pp. 420–423, Feb. 17, 1902.)—The author finds that the rays from radium and the Röntgen rays act on dielectric liquids as on air and communicate to them a certain electric conductivity. Results of the same order of magnitude were obtained with both these kinds of rays. The current produced through air when rendered conducting increases proportionally to the potential difference when this potential difference is small. When, however, it is increased the strength of the current no longer increases in proportion. Dielectric liquids behave in a similar way, but the current remains proportional to the potential difference up to a limit which is much higher than in the case of gases. J. J. S.

1067. *Röntgen Rays.* **W. Rollins.** (Elect. Rev. N.Y. 40. p. 12, Jan. 4, 1902.)—A method is described of adjusting the character of a tube by electrically heating a substance contained in the tube, for example, potash, and regulating the temperature of the platinum wire which heats that substance so as to adjust the balance between the emission of particles (*e.g.*, water vapour) from that substance and their reabsorption by it. A. D.

1068. *Destructive Ulceration produced by Röntgen Rays. Treatment by Red Rays.* **P. Bar** and **Boullé.** (Revue Int. d'Electrothérapie, 11. pp. 321–329, Nov. and Dec., 1901.)—An application of Röntgen rays was made to the abdomen of a woman for the relief of pain. It lasted twenty minutes ; the tube was 6 in. from the skin. Eighteen days later a red blush became visible at that part. It ran a course of two or three weeks, became slightly ulcerated, and healed up. Two months after the exposure to the rays it broke down anew and gradually a large ulcerated surface formed, which was sloughing in the centre and refused to heal. Five months after the exposure to the Röntgen rays, an injection of saline solution was made at a distance of several inches from the margin of the ulcer, and this became the focus of a second extensive slough and ulceration. Treatment eventually was tried by exposure to red rays. The trunk and hips of the patient were enclosed in a box with a window of red glass. This was so adjusted that sunlight could shine upon the ulcerated surfaces through the red glass, and the patient was so arranged in a sunny room that the sun's rays could fall

upon her for the greater part of the day. Healing soon commenced, and was complete in less than two months. The injections of saline solution were performed on account of the condition of health of the patient, who had recently been confined. They were repeated five times, four times in the thighs and once in the abdomen. Only the injection into tissue which had been exposed to the Röntgen rays proved disastrous, no doubt by reason of the changed condition of nutrition in that part. The authors cite another case to show that Röntgen ray exposures leave behind them a special vulnerability of the tissues. A man visited a thermal station six months after exposure to a treatment by Röntgen rays. He was treated there by douches of hot water in the customary manner, but the second application provoked ulceration in the part which had been subjected to Röntgen rays, and the ulceration took six months to heal. L. J.

1069. *Accidents caused by Röntgen Rays.* **Oudin.** (Annales d'Électrobiologie, 4. pp. 453–469 and 5. pp. 572–610, 1901.)—In describing the injuries to the skin which follow prolonged exposure to Röntgen rays, the author divides the changes into three periods : first, the period of erythema which appears about twenty-four hours after exposure and may last from ten to twenty-five days ; second, the period of vesicles or blisters ; these are accompanied by pigmention of the surrounding skin, and discharge a yellowish serum ; this period lasts ten days or more, and there may be a loss of the hairs of the affected part during its continuance : third, the period of superficial ulceration ; and fourth, the period of the formation of adherent necrosed sloughs. After this come the periods of deep ulceration and of slow cicatrisation. Characteristics of these cases are the intense irritation of the first stage, and the severe pains of the second and later stages. No known form of healing application seems to be of the slightest use for hastening recovery. The pains are relieved in part by applications which protect the surface from contact with air. A year or longer may elapse before healing. There is also a chronic form of Röntgen-ray burn which affects the hands of those who are much engaged about Röntgen-ray tubes. In this form the skin becomes gradually thickened, red and cracked, the hairs fall out, the nails become scaly and fall off. Unless precautions are taken, the hands become ulcerated and painful. The author affirms that the changes are due solely to the Röntgen-ray radiations, and not at all to the electrical discharges around the tube. The risk of accident is proportionate to the richness of the emission of Röntgen rays from the tube, to the nearness of the tube to the skin, and to the duration of the exposure or exposures. The "soft" tube of low resistance is far more likely to cause burns than a "hard" tube. Tissues which have been exposed to a course of Röntgen-ray treatment are rendered extremely vulnerable, and great care must be exercised in applying any treatment to them for a long time afterwards. L. J.

REFERENCE.

1070. *Photometric Apparatus.* **M. Herschkowitsch.** (Zeitschr. Instrumentenk. 21. pp. 364–366, Dec., 1901.)—The author's photometric apparatus is described, and minutely compared with that of H. Krüss, on the same principle. L. G.

HEAT.

1071. *Comparison of Platinum and Hydrogen Thermometers.* **B. Meilink.** (Konink. Akad. Wetensch. Amsterdam, Versl. 10. pp. 495–501, Feb. 22, 1902.)—This paper forms a part of a more general investigation, the problem treated here being that of an accurate expression of the resistance as a function of the temperature for a standard metal by comparing the platinum thermometer with the hydrogen thermometer. The arrangement of the resistance thermometer is given, temperature determinations being made to within 0·02° C. under favourable circumstances. The precautions necessary to bring the platinum wire and the hydrogen thermometer under the same conditions and to keep them for a long time at a constant temperature are indicated.

The heat due to the Joule effect and the influence of radiation and conduction of heat are diminished by bringing the wire into immediate contact with the liquefied gas. As naked wires were used, care had to be taken that the liquid bath should be a good insulator. The resistance consisted exclusively of glass and metal, so as to avoid the use of such substances as are liable to be attacked by liquefied gases. The Wheatstone bridge used is described, the means of eliminating the influence of contact resistances being pointed out. Finally, the operations necessary for determining the zero are carefully discussed. A. G.

1072. *Expansion of Mercury.* **L. Grunmach.** (Phys. Zeitschr. 3. pp. 134–136, Jan. 1, 1902. Paper read before the Versammlung deutsch. Naturforscher u. Aerzte, Sept. 25, 1901.)—An alcohol thermometer was made, and its readings between 0° and —80° compared with a standard. This was then filled, half with mercury and half with alcohol, and a fresh series of readings taken. The results are embodied in a series of curves. It is shown that between —38°·5 and —33°·7, when melting is taking place, the expansion is 86·50 times larger than for solid, and 58·68 greater than for liquid mercury. The expansion of solid mercury is 0·6784 that of the corresponding liquid. Melting increases the volume by about 5 per cent. R. S. W.

1073. *A Sensitive Thermostat.* **W. P. Bradley** and **A. W. Browne.** (Journ. Phys. Chem. 7. pp. 118–135, Feb., 1902.)—The heating is caused by the circulation of warm water produced by a rapidly revolving propeller, and the regulator consists of a glass spiral, 4 m. long and 5·5 mm. in bore (and therefore with 700 sq. cm. of surface), containing ethyl alcohol. The best results are obtained when the inflow is only "throttled" and not cut off. The water is itself heated in a thermally regulated reservoir, but its temperature in the reservoir may vary by $\frac{1}{2}^\circ$ without affecting the regulation, which has a sensibility of 0·001°. R. E. B

1074. *A Form of Electric Thermometer.* **G. Meslin.** (Comptes Rendus, 134. pp. 412–414, Feb. 17, 1902.)—The paper describes a method of determining the temperature of a place where the ordinary thermometer cannot be directly observed. The variation with temperature of the e.m.f. of a Clark cell is made use of. The e.m.f. of the cell placed in the region whose temperature is to be observed is balanced against a known e.m.f. by a potentiometer arrangement. J. J. S.

1075. *Gas-thermometry.* **P. Chappuis.** (Phil. Mag. 3. pp. 243–247, Feb., 1902.)—I. A recalculation of the boiling-point of sulphur from Harker and Chappuis' former observations, when Holborn and Day's new measurements of the expansibility of Berlin porcelain are employed, gives 444·7° (instead of 445·2°), which is very close to Callendar and Griffiths' value. II. The coefficient $(\partial P/\partial t)/P_0$ for nitrogen, when P_0 is 1 m. of mercury, diminishes to a limiting value 0·00367380, which is reached near 75°, after which temperature the gas may be assumed to be perfect. Then, since $P_{100} = 1{\cdot}367466$, we have, for temperatures over 75°,

$$P = 1{\cdot}000086 + 0{\cdot}00367380t = 1{\cdot}000086(1 + 0{\cdot}00367348t),$$

or the corresponding ideal gas-thermometer would have $P'_0 = 1{\cdot}000086$ and $\alpha' = 0{\cdot}00367348$; and to reduce the readings τ of the unconverted nitrogen scale to this ideal scale we must add $0{\cdot}000234(\tau - 100)$. [See also Abstract No. 76 (1901)]. R. E. B.

1076. *Empirical Formula for Isothermals.* **J. E. Verschaffelt.** (Archives Néerlandaises, 6. pp. 650–656, 1901.)—The isothermals of carbon dioxide are found to be represented by formulæ of the form $p = p_1 + m(x - x_1) + a(x - x_1)^n$, where $x = 1/(v - b)$, b has the same value, 0·00045, as at the critical temperature, and the other constants are different for different temperatures. These constants are calculated for various temperatures above and below the critical temperature, and tables are given showing an agreement between the observed and calculated values of p, which the author considers within the limits of experimental error. W. E. T.

1077. *Ternary Systems, I.* **van der Waals.** (Konink. Akad. Wetensch. Amsterdam, Versl. 10. pp. 544–560, Feb. 22, 1902.)—This is the first part of a theoretical investigation of ternary systems. The equilibrium phenomena at a given temperature of a binary system have already been set forth by the author. Now in a ternary system, the method of expressing the free energy ψ in terms of volume and composition fails to afford a geometrical representation of those phenomena ; the author therefore suggests making use of the property of the ζ-function to exhibit a minimum value for given values of T and p, according to Gibbs' phase-rule. In a ternary mixture, made up of $1 - x - y$, x and y molecules of the three components respectively, the value of ζ (see Arch. Néerl. Sér. II., tome 2, p. 71) will be given by the equation—

$$\zeta = \mathrm{MRT}\{(1 - x - y)\log(1 - x - y) + x\log x + y\log y\} +$$
$$+ \{pv - \mathrm{MRT}\log(v - b_{xy}) - a_{xy}/v\} + \mathrm{A}x + \mathrm{B}y + \mathrm{C}$$

It had previously (*l.c.*) been pointed out that such ζ surfaces will, as a rule, consist of three sheets, of which, however, only one represents states capable of being experimentally realised, the remaining ones being either metastable or unstable, although, in order to show the principle of continuity, they cannot be dispensed with.

From the differential equation, $d\zeta = vdp$, the author derives for a molecular quantity in the diluted gaseous state at a given temperature—

$$\zeta = f(\mathrm{T}) + \mathrm{MRT}\log p,$$

or—

$$\zeta = \mathrm{MRT} + \mathrm{MRT}\log(p/\mathrm{MRT}),$$

the vapour branch of the ζ-curve thus climbing up, with increase of p, from

$-\infty$ for $p = 0$, as represented by $a\,c\,b$ in Fig. 1, where e is the common point of the vapour and liquid branches. The further course of the liquid branch may easily be established by means of the equation $d\zeta = v\,dp$, while, by applying the principle of continuity, the continuation of the vapour branch, the unstable branch, and the beginning of the liquid branch $c\,e$ are to be found, b and c being inversion points. As long as the pressure lies between the two limits p_u and p_m (maximum and miniumum pressures of the isothermal), ζ will have a triple value. In the case of a homogeneous mixture, the ζ-curve is found to have the same form, the three values of ζ coinciding, as soon as T exceeds what is termed the critical temperature of the mixture. In order next to ascertain the connection between the different sheets of the ζ-surface of a ternary mixture at given values of T and p, the author first considers the three curves situated in the plane $y = 0$, which is equivalent to seeking the connection between the three values of ζ for a binary mixture. Let (Fig. 2) the curve ABPB′A′ thus be the connodal line of a binary mixture in a x, v diagram, R being the critical point of contact, and P the folding-point. From A to P, as well as from A′ to P, the pressure of the coexisting phases

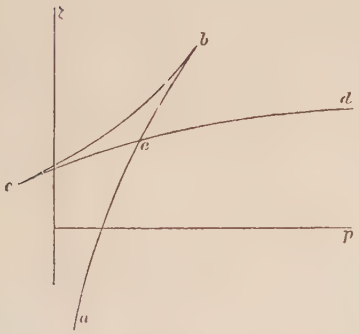


FIG. 1.

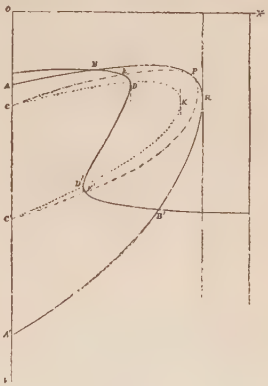


FIG. 2.

of the binary mixture will increase. On the Figure, in addition to this connodal line and to the isopiëst crossing the points B and B′, there is plotted the curve CPC′, representing the limit of the stable and unstable homogeneous phases, this curve being defined by the equation $\partial^2\zeta/\partial x^2 p = 0$. Finally (CKC′) there is shown the curve $-\partial p/\partial v = \partial^3\psi\partial v^3 = 0$, lying wholly within the former line. The point K may be considered as a vertical point of the mixture regarded as undecomposable. The course of the isopiëstic is next followed, with the result that for the chosen value of p there will exist a continuous series of phases of the binary mixture, the liquid and gaseous phases lying on the left side of B, and on the right side of B′ respectively. Metastable phases are to be found between B and E and between E′ and B′, whereas E and E′ will comprise the unstable phases. In the original paper a curve is given representing ζ as a function of x, at this pressure and this temperature, and it is shown how an existing complication in this curve may disappear. The author next investigates the case of a propagation of a similar complication, by considering the consequence of the pressure diminishing. He then proceeds to discuss the signification of the double point of the ζ-curve and of the displacement of the inflexion-point. The foregoing discussion affords a means of studying the geometrical configuration of the ζ-surface in the case

of a ternary system, and more especially at the critical circumstances of the gaseous and liquid states. The modifications shown in this case by the curves above mentioned are rapidly dealt with, the fold observed in the former case being substituted by a configuration termed "three-sheets fold."

From this geometrical discussion the following conclusions are drawn: the critical phenomena of a ternary system are equal to those of a binary system. At the chosen temperature all those mixtures will exhibit a special folding-point configuration indicated by the course of the point P, as stated in the original paper, the corresponding pressure being different for different mixtures. The limiting value of $(y_2 - y_1)/(x_2 - x_1)$ is given by the direction of the tangent in P to the connodal line. The mixtures corresponding, at the chosen temperature, to contact points are found by means of the envelope of the different binodal lines, those figured by points situated between the P-curve and the above envelope exhibiting retrograde condensation of the first species.

A. G.

1078. *Change in Molecular Volume of Dissolved Salts with Temperature.* **C. Forch.** (Phys. Zeitschr. 3. p. 183, Feb. 1, 1902.)—If a litre of an aqueous solution of specific gravity s at $t°$ C. contain mA grammes of a salt whose equivalent weight is A, and if Q be the specific gravity of water at $t°$ C., then the "molecular volume" ϕ of the dissolved salt (that is, the volume of a gramme-molecule, or for salts of dibasic acids half of this volume) is defined by the relation $\phi = A/Q - 1000(s - Q)/mQ$. Denoting by ds and dQ the changes in s and Q per degree rise in temperature we obtain the temperature coefficient of ϕ—

$$d\phi = \left(\frac{1000\,s}{m} - A\right)\frac{dQ}{Q^2} + 1000.\frac{s - Q}{Qm^2}.dm - \frac{1000}{mQ}.ds,$$

where dm is the change in concentration per unit rise in temperature and is equal to the negative value of the coefficient of expansion of the solution. Taking the results of different experimenters for various salts, the author points out that the temperature coefficient of ϕ decreases very rapidly with increase in temperature, corresponding to the fact that the coefficient of expansion of a salt solution at comparatively high temperatures is less than that of water. The temperature coefficient is practically independent of the magnitude of the molecular volume itself, almost independent of the dissolved substance when the number of gramme-molecules dissolved and the temperature interval are the same, and for values of ϕ ranging from + 210 to − 3 approximately the same for all bodies dissolved in water. A distinct dependence on the degree of dissociation cannot be traced. The "temperature coefficient of the molecular volume" seems therefore to be determined rather by the solvent than by the properties of the dissolved substance.

W. S.

1079. *Vapour-Pressures of Carbon Dioxide and of Ethane at Temperatures below 0°.* **J. P. Kuenen** and **W. G. Robson.** (Phil. Mag. 3. pp. 149–158, Jan., 1902.)—The low temperatures required in the measurement of these vapour pressures were obtained by means of sulphur dioxide and ammonia boiling under reduced pressure, the temperature being determined by a platinum thermometer. Vapour pressures are given for liquid carbon dioxide at temperatures varying from 0° to − 63·13° and for the solid from − 57·86° to − 78·32°. The triple-point diagram for carbon dioxide is given,

this point being determined directly by changing the temperature until no gradual change in the amount of solid is observable, and indirectly by finding the point of intersection of the solid-vapour and liquid-vapour curves ; the two values thus obtained are identical, the triple-point temperature being — 56·2° and the pressure 5·10 atmospheres. The liquid may be considerably undercooled as the lowest liquid-vapour point is 7° below the triple-point temperature. The numbers obtained for the vapour-pressures of ethane are not considered as accurate within 1 per cent. owing to the great difficulty of purifying the gas. T. H. P.

1080. *Determination of Freezing-points of Solutions.* **K. Prytz.** (Kongl. Danske Vidensk. Selsk. Kjöbenhavn, Forh. No. 1, pp. 17–30, 1902.)—The author has devised a method analogous to that used in the case of pure water, enabling freezing-points to be determined at temperatures maintained constant for any desired time. A double-walled Dewar vessel is filled up with finely pounded ice, and contains a thin helical brass tube surrounding a Beckmann thermometer, through which a constant supply of solution is allowed to enter the vessel and to overflow at its edge. The author shows that the temperature registered will tend asymptotically towards the freezing-point of the solution. The possible causes of error are enumerated, and necessary precautions discussed. This method allows of a direct determination of the zero of the thermometer, *i.e.*, of the freezing-point of the water used as solvent, by employing in a preliminary experiment pure water instead of solution. It seems to be preferable to the well-known suffusion method, as the latter gives reliable results only when the formation of ice and the loss of heat through absorption by and radiation from the walls of the vessel may be neglected. An approximate value is given for the quantity of heat traversing the evacuated space between the walls of the vessel. A. G.

1081. *Supercooling of Liquids.* **P. Bachmetjew.** (Phys. Zeitschr. 3. pp. 195–196, Feb. 1, 1902. Paper read before the 73rd Naturforscherversammlung at Hamburg, Sept. 25, 1901.)—This paper describes experiments and results similar to those given in Abstract No. 1653 (1901), but made with benzene and water, and also with insect juices. The different drops of suspended liquid solidified at different temperatures and the difference in behaviour is not due to differences in interior temperature or the like in the suspending liquid, but is probably to be explained by polymorphism in G. Tammann's sense of the word. D. H. J.

REFERENCES.

1082. *Thermostats and Thermoregulators.* **W. C. Geer.** (Journ. Phys. Chem. 7. pp. 85–105, Feb., 1902.)—A review of the thermostats dependent on the equilibrium of coexisting phases, and of the main types of automatic and non-automatic thermoregulators, which have hitherto been employed, is first given, and then a description of an efficient thermoregulator for controlling (to a sensibility of 0·002°) the temperature of an electrically heated thermostat. R. E. B.

1083. *Partition of Energy between Ether and Matter.* **M. Planck.** (Archives Néerlandaises, 6. pp. 55–66, 1901.)—In this paper the author sets forth the arguments and conclusions of former papers in a slightly modified form. [See Abstract No. 1284 (1901).] G. W. DE T.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

1084. *Electrodynamics of Bodies in Motion.* **E. Carvallo.** (Comptes Rendus, 134. pp. 165–168, Jan. 20, 1902.)—The writer claims to have discovered or rediscovered for bodies at rest the following laws : (1) The flux of the total electric current through any closed surface is zero. (2) The line integral of electromotive force round a closed curve is zero. In the present paper he discusses the electromotive force of induction due to movement of matter, as to which he says that in the case of conductors and electrolytes the force is the vector $(\dot{x}\ a)$, where $\dot{x}$ is the velocity of matter, and a the magnetic induction ; and for dielectrics he refers to M. Blondlot as having recently found the solution. In Section 4 he treats the electrodynamic equations for bodies in motion, namely, $\frac{du}{dx} = 0$, the equation of continuity, and—

$$\frac{dU}{dx} = a' - \frac{d}{dx} V(x'a)$$

a' being $\frac{da}{dt}$ and U the electromotive force. In conclusion he claims to have extended the two fundamental equations established for bodies at rest to bodies in motion, and to have given the electrodynamic equations for bodies in motion. The equation of energy, he says, is dealt with as in ordinary mechanics. S. H. B.

1085. *Magnetic Field due to Electric Convection.* **A. Righi.** (N. Cimento, 3. pp. 71–80, Jan., 1902.)—It is not yet possible to explain the entirely negative results of Crémieu, as compared with the positive results of others ; but one point arises in considering the reasonings of the latter. It is assumed that putting a metallic diaphragm between the moving charges and the needle screens off any direct electric action, but does not affect the magnetic force. If it did at the same time suppress the magnetic force, Crémieu's negative results would be explained ; but the positive results of others would remain unexplained. It was important, therefore, to know what was the electromagnetic field produced beyond an infinite conducting-plane by a charge moving uniformly in a straight line. This has been thoroughly worked out by Professor Levi-Civita in a paper to be published in the Annales de la Faculté des Sciences de Toulouse. The general result is that the conducting diaphragm, on being interposed, weakens the magnetic field beyond it, reducing it to zero if the diaphragm be infinitely conducting. The magnetic field would be reduced, say to 8 per cent., by a copper diaphragm, say to 49 per cent., by a tinfoil diaphragm. Nearly all experiments have, however, not corresponded to this case, but to a condition of stationary convection in which there is no such reducing effect ; with the exception of those of Adams, who did not employ a conducting disc divided into sectors, but a number of charged metallic spheres mounted on the circumference of a rotating wheel. In this case the magnetic force must be greatly reduced by the diaphragm. [See also Abstract No. 481 (1902).] A. D.

1086. *Motion of an Electrified Particle in the Electromagnetic Field.* **E. Riecke.** (Phys. Zeitschr. 3. pp. 182–183, Feb. 1, 1902.)—The problem considered is of interest in connection with certain of the author's experiments not yet published. He supposes an infinitely long cylindrical kathode of radius a, the electrostatic equipotential surfaces being cylinders coaxial with this kathode. The magnetic field is uniform, of intensity H, and its direction is parallel to the axis of the kathode. The author investigates the motion of a particle of mass m possessing a negative electrostatic charge of e units, the particle leaving the surface of the kathode with zero velocity. Then if V_a, V be the electrostatic potentials at the surface of the kathode and at distance r from its axis respectively, v the ratio of the electromagnetic to the electrostatic unit of quantity, it is shown that the path of the particle lies in a plane perpendicular to the axis of the kathode, and that the radial velocity vanishes at a distance r given by $r - a^2/r = (2v/\mathrm{H})\sqrt{2m(\mathrm{V} - \mathrm{V}_a)/e}$, the particle moving afterwards in a circle of radius r. The previous path is a spiral approaching this circle asymptotically. The greater the magnetic field intensity the smaller the radius of the circle. The result is in close relation to the contraction of the dark space in the magnetic field. W. S.

1087. *Effect of Nature of Surface on Contact Electricity.* **N. Hesehus.** (Jurn. Russk. Fisik. Chimicesk. Obscestva, No. 1*b*, pp. 1–15, 1902.)—By means of an extensive series of experiments on disks of various metals, the author shows how a polished surface will in all cases be positive with respect to a matt surface of the same substance. This is equally true of non-metallic bodies; among the experiments made in this direction, those performed with different kinds of wood are particularly interesting, the result arrived at being that a plate cut perpendicularly to the fibres will be negative with regard to a plate of the same material cut parallel to the fibres, the latter possessing a higher polish. As regards the case of two disks of different substances brought into contact, the author establishes the interesting proposition that a metal will prove the more positive, as its hardness is less, while on the other hand a non-metallic body exhibits a negative potential difference with respect to a softer material. For both classes of substances very full series are given. Some apparent exceptions to this rule are easily explained by taking into account either the hygroscopic properties of those bodies, it being shown that a wet plate will be positive with regard to a dry one of the same material, or the law that of two different superficial modifications of a body the one possessing a higher superficial density will be positive with regard to the other. Thus, viscid substances, or substances capable of giving off dust, will always be positive, whatever body they are brought into contact with; dust will in all cases exhibit a negative p.d. with respect to the body it is taken from, because its superficial density is less. Many atmospheric phenomena may be interpreted by taking account of the electrification of dust. Finally the well-known fact that two pieces of quartz or other substances when struck together will shine in the dark, is investigated, the result being that both pieces will carry a positive charge, an almost invisible layer of dust negatively charged being interposed between them. [See also Abstract No. 319 (1902).] A. G.

1088. *Crystallisation under Electrostatic Stress.* **P. R. Heyl.** (Phys. Rev. 14. pp. 83–88, Feb., 1902.)—It was thought possible that electrostatic stress might act on crystals formed under its influence so as to alter the interfacial angles and probably also the density. HgI_2, a salt sensitive to slight

mechanical disturbances, was employed as indicator, but no effect was found. Hence, negatively, electrostatic stress does not affect crystallisation, or, positively any molecular forces called into play in a solution under electrostatic stress are not comparable with the forces of crystalline attraction. R. S. W.

DISCHARGE AND OSCILLATIONS.

1089. *Constitution of the Electric Spark.* **G. A. Hemsalech.** (Journ. de Physique, 1. pp. 76–90, Feb., 1902.)—An analysis of the investigations of Schuster and Hemsalech, and of the latter alone, on the electric spark. [See Abstracts Nos. 1066 (1900) and 1510 (1901). Much of the contents of the present paper is already dealt with in the latter of these two Abstracts.] An electric spark is produced in the following manner: The layer of air between the two electrodes is first pierced by the initial discharge; then the air in the immediate neighbourhood of the path traversed by the discharge becomes incandescent: this is the "luminous path." But immediately afterwards the space between the electrodes becomes filled with metallic vapour produced by the initial discharge: this is the "aureole." The oscillations following the initial discharge traverse this vapour and reheat it. If self-induction be put in the circuit, with increase of self-induction the form of the "aureole" becomes more and more regular, while the initial discharge becomes more and more feeble. Without self-induction, the discharge is abrupt and almost all the energy is in the initial discharge; with self-induction, the induced currents prevent a rapid discharge. Almost all the energy is spent in heating the metallic vapour; it is only the feeble initial discharge which traverses the air, and its strength is not great enough to heat the air to incandescence although sufficiently strong to produce metallic vapour. With an iron or copper tube inserted as core of the induction coil, the oscillations of the discharge are destroyed and we have a single discharge. This is due to magnetism of the iron and to Foucault currents; in the case of iron, both causes are at work, and their effects are added, while in the case of copper, only the Foucault currents are operative. W. C. H.

1090. *Action of Incandescent Metals in Producing Electric Conductivity in Gases.* **J. A. McClelland.** (Cambridge Phil. Soc., Proc. 11. pp. 296–305, Feb., 1902.)—The paper contains an account of some experiments on the nature of the conductivity produced in gases by the action of incandescent metals. Results are given and curves plotted for the case of an incandescent wire in air at atmospheric pressure and at reduced pressure. At atmospheric pressure, positive carriers appear in the gas near the wire before negative carriers, but when the temperature is sufficiently high, carriers of both signs are given off, and are approximately equal in amount at very high temperatures. At reduced pressure, when the wire is heated by a current and at the same time is raised to any required negative potential above that of a cylinder surrounding it, the current between wire and cylinder at first rises proportionately with the potential difference, then shows signs of reaching a maximum, and afterwards increases rapidly. This second increase is explained by secondary ionisation caused by collisions between negative carriers and molecules. With the wire charged positively, a similar effect is observed, indicating that the positive ions travelling out from the wire have produced secondary ionisation. As the e.m.f. for which this secondary ionisation begins, is not very different in the two cases, it appears that the masses in the two cases are not very different. The experiments on ionisa-

tion in air by Röntgen rays or ultra-violet light, on the other hand, all show that the negative ion is very small compared with the molecule, while the positive is of molecular magnitude. These results obtained by the author are for a pressure of $\frac{2}{3}$ mm. At a pressure of $\frac{1}{10}$ mm. a smaller voltage is sufficient to produce ionisation by collisions of the negative ion than that required to give the necessary velocity to the positive, but the experiments show that the positive ion can be given the velocity necessary to produce ionisation. In these experiments with a hot wire there are many indications that we are dealing not only with ions produced from the molecules of the gas, but also with ions actually given off from the hot wire itself. Thus at a pressure of 1 mm. or less, the current, when the wire is negative, may be 50 times what it is when the wire is positive, and such a difference from what is observed at atmospheric pressure suggests that, at low pressure, we get a copious supply of negative ions from the wire itself. Again, as the current with wire negative was practically constant when the pressure was varied from $\frac{1}{25}$ mm. to $\frac{1}{250}$ mm., it may be suggested that, at such pressures, the ions from gas molecules are small in number compared with those coming from the wire. Possibly the positive ions producing secondary ionisation also come from the wire, and this may account for the apparent difference between them and the positive ions investigated in other cases of ionisation. Further experiments on the subject are promised. [See also Abstract No. 1854 (1900).]

W. C. H.

1091. *Negative Radiation from Hot Platinum.* **O. W. Richardson.** (Cambridge Phil. Soc., Proc. 11. pp. 286–295, Feb., 1902.)—McClelland has shown that the electric radiation from hot platinum is invariably negative, whatever the surrounding gas. This suggests the idea that in the negative radiation at high temperatures the phenomenon of conductivity produced by metals takes its simplest form. Considering, then, the negative ions as moving freely in the metal, like air molecules in the atmosphere, subject to the speed-law $dn = n\,(km/\pi)^{\frac{3}{2}} \exp.\left\{-km\,(u^2+v^2+w^2)\right\} du\,dv\,dw$, where n is the number of ions in unit volume, $3/4k$ the energy of an ion and m its mass, and Φ the work done by an ion in escaping through the surface-layer of the metal where we must suppose a discontinuity in the potential which hinders the escape of the ions, the number of ions which escape per unit area per second is—

$$N = \int_{\sqrt{(2\Phi/m)}}^{\infty} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} u\,dn = \tfrac{1}{2}\,n\,(km\pi)^{-\frac{1}{2}} e^{-2k\Phi} = n\,\sqrt{(R\theta/2m\pi)}\,e^{-\Phi/R\theta}$$

since $k = (2\,R\,\theta)^{-1}$, where R is the gas-constant for a single ion. The saturation current s of the negative radiation should therefore on this theory obey the law $s \propto \theta^{\frac{1}{2}}\,e^{-b/\theta}$, where b is a constant. Experiments were therefore made to determine the saturation currents from a hot platinum wire at various temperatures θ (abs.), when placed concentrically with an aluminium cylinder in a bulb which was exhausted to pressures between 0·01 and 0·16 mm. of mercury, and these were found to fully confirm the theoretical law. They further allowed the following estimates to be made, viz., that the number of free negative ions in a cubic centimetre of platinum at 1,269° C. is $1{\cdot}3 \times 10^{21}$, and that there is a discontinuity in the potential at a platinum-vacuum surface amounting to 4·1 volts.

R. E. B.

1092. *Coronas of Cloudy Condensation, and Contrast of Axial and Coronal Colours.* **C. Barus.** (Amer. Journ. Sci. 13. pp. 81-94, Feb., 1902.)—The

author describes his further researches on the coloured coronas formed in moist nucleated air in contact with a steam jet. The tubular apparatus used in early experiments was discarded, a spherical receiver being found preferable for studying coronal effects. "With divergent sunlight the display is gorgeous, the colours glowing metallically." The changes which the coronal colours undergo, as the number of nuclei is decreased by a process of successive exhaustion, are tabulated. The effects due to loss of nuclei with lapse of time, when the receiver is left for long intervals without exhaustion, are also discussed. For studying the axial colours, *i.e.*, the colours of the steam jet, a double conical dram (apices outwards) was used. Calculations are given relating to the size of the water particles, and of the nuclei. [See also Abstracts Nos. 691 and 871 (1902).] A. E.

1093. *Radio-activity in Atmospheric Air.* **H. Geitel.** (Archives des Sciences, 13. pp. 113–128, Feb., 1902.)—A summary is given of the previously published researches of the author and J. Elster on the dissipation of electric charges from bodies placed in air, on the conductivity produced in air by radio-active substances, and on various phenomena of radio-activity. The experiments carried out lead the authors to the conclusion that any conductors placed in a large mass of air, on being charged negatively, become covered with a superficial layer possessing temporary radio-activity. Experiments conducted in natural caves and in a large disused cellar where the air had been in repose for months and where there was complete absence of radio-active substances, showed a remarkable conductivity possessed by the air in these circumstances. It is suggested that the existence in the air, and gases in general, of ions capable of forming combinations with the negative electrons at the surface of conductors may be the primary phenomenon from which that of radio-activity should be deduced. The question then arises if it is possible also to combine the negative ions of the air with the positive electrons of electrified conductors. Up to the present time it has not been found possible to obtain on conductors charged positively superficial layers presenting properties analogous to those which are met with in the case of negative conductors. [See also Abstract No. 1918 (1901).] J. J. S.

1094. *Magnetic Tubes of Force made Visible by Kathode Rays.* **H. Pellat.** (Comptes Rendus, 134. pp. 352–355, Feb. 10, 1902.)—The author finds that when the kathode has the form of a disc in an intense magnetic field the rays emanating from the kathode delineate exactly the tube of magnetic force having the surface of the kathode for base, the rays leaving the whole surface of the disc uniformly. The phenomenon is quite distinct from that presented by the anode rays, which have also a tendency to follow the lines of force of the field, but issue from the edge of the anode, and do not represent a magnetic tube of force. The kathode rays obeying the above law, the author calls the flux A, to distinguish them from another set of kathode rays (flux B), different in colour and in other properties. [See also Abstract No. 815 (1899).] The flux A experiences no electromagnetic action tending to deflect it at right angles to the lines of force, be the field intense or weak. It always leaves the kathode in the direction of the field, whether that direction be normal, oblique, or tangential to the surface. In zero field and weak fields (up to 300 c.g.s.) the flux A leaves the kathode in all directions, and on both sides, forming a sort of atmosphere round it. The figure formed by the flux A is independent of the sense of the field; it is otherwise for the anodic flux and the flux B. The distinctness of the lateral part of the tube is

independent of the pressure of the gas so far as the author's experiments go (4 mm. to 0·004 mm). At 3,000 c.g.s. no want of continuity could be detected by a lens. At 300 c.g.s. nothing could be clearly distinguished. The author goes on to describe in detail the appearances at different pressures. The spectrum of the violet light due to the flux A was examined at a pressure of about 0·5 mm.; only radiations due to air were observed, none of the radiations characteristic of aluminium or its impurities. W. S.

1095. *Transparency of Conducting Liquids for Hertzian Waves.* **C. Nordmann.** (Comptes Rendus, 134. pp. 417–420, Feb. 17, 1902.)—The author has confirmed and extended his experiments on the absorption of Hertzian waves by electrolytes. [See Abstract No. 2376 (1901).] He finds that the maximum thicknesses after traversing which the Hertzian waves employed are still sensible, that is the transparencies for these waves, vary in the same sense as the resistances; they increase less quickly than these latter and more quickly than their square roots. J. J. S.

1096. *Application of Thermal Galvanometers to the Study of Electric Waves.* **L. de Broglie.** (Comptes Rendus, 134. pp. 349–352, Feb. 10, 1902.)—The author has studied the circumstances under which thermal ammeters can be employed in the study of wireless telegraphy. The transmitter was that of the wireless telegraph station at Saint Louis, having an antenna 24 m. in vertical height, and joined to earth through an induction coil. Between the base of the vertical transmitter and the induction coil could be inserted a known number of brass wire coils 30 cm. in diameter. The receiver, about 30 m. distant, was also vertical, and joined by its lower extremity to one terminal of a milliammeter, the other terminal of which was joined to earth by a short wire. Between the base of the receiver and the milliammeter could be inserted any required number of closely-packed wire coils on a wooden base 5 cm. in diameter. When a disturbance was propagated from the transmitter a deflection was obtained on the milliammeter, which attained a very distinct maximum for a certain number of coils added between the receiver and the instrument. If a certain number of coils were added to the emitter, a *proportional* number had to be added to the receiver to secure the maximum deflection. The author also investigates the effect of modifying the emitted wave in various ways, *e.g.*, by varying the spark-length or the number of brass wire coils added, or by replacing the single vertical wire 24 m. long by other antennae of equal length, such as an antenna consisting of four branches. When the transmitter was replaced by a wire 40 m. long two maxima separated by a minimum were found in place of the former maximum, the absolute value of the largest of those two maximum deflections being decidedly less than the former maximum. The author investigates also the effect of varying the type of receiver, *e.g.*, by using a single wire or a number of wires in parallel, and of winding a secondary coil round that added between the receiver and the amperemeter. W. S.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1097. *Elimination of Corrections for Leads in Cable Testing.* **H. Savage.** (Elect. Rev. 50. pp. 86–88, Jan. 17, and pp. 124–125, Jan. 24, 1902.)—In capacity tests the deflection on the lead is taken with the galvanometer unshunted, and when deducted from reading of cable it is divided by the multiplying power of the shunt used on the latter. Thus if the deflection on the lead $= d$, deflec-

tion of cable with galvanometer shunted = D, true deflection on cable = D_t, and multiplying power of the shunt = n, then $D_t = D - d/n$. This is true for a simple shunt arrangement, but if the leads from the keys, &c., to the galvanometer have any appreciable capacity, it is not strictly so for "universal" shunts. In using the latter care must be taken to see that the connections are made as in Fig. 1. The current must enter at one terminal of the fixed resistance R. If d_{gl} = deflection due to galvanometer leads, and d_u = that due to the testing lead, then $D_t = D - (d_{gl} + d_u/n)$. But if the connections are reversed, d_{gl} will vary. The correction for the testing lead makes the results of insulation, electrification, and loss of charge readings uncertain. To eliminate this, the author adopts an extension of Price's guard-wire system for cable ends. He applies a surrounding or concentric conductor to the whole lead, insulated from the inner. The outer is joined direct to the battery. The inner and outer being practically at the same potential, there will be no deflection due to leakage between them, and that between outer and earth does not affect the galvanometer. In capacity tests it is necessary to charge the two conductors together and to insulate them simultaneously,

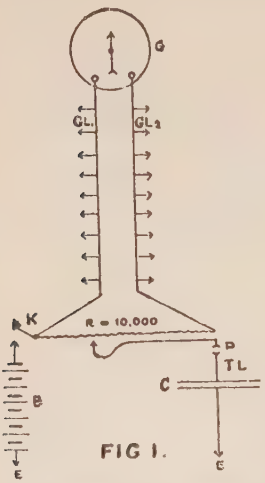


FIG 1.

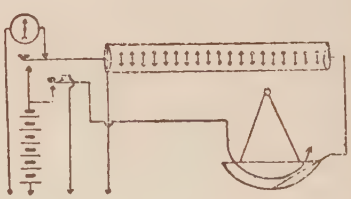


FIG. 2.

but to discharge the outer direct to earth immediately before discharging the inner through the galvanometer. The author considers that the concentric lead affords complete shielding from induction effects of neighbouring leads, and the outer being of fine copper wires is more flexible and more convenient than one with a lead covering or metal taping as commonly used. The concentric lead is also useful for joint testing, by using it as a condenser to collect the leakage from the joint. The required connections are shown in Fig. 2. The outer is earthed, the inner joined to a plate in the trough. The latter is charged with a few cells, and discharged deflections noted; again charged, insulated for a minute, and again discharged. If the loss is small, the insulation of the trough is good. The cable is charged, say, with 300 cells. This will give a deflection due to capacity of the joints. Leaving the battery on the cable, the inner is now insulated for a minute, the leakage from the joints then accumulating in the lead. After a minute this is discharged and the deflection compared with a standard length of good core. In this test the ends of the inner must be well insulated. A diagram of a system of keys arranged to meet all these conditions is given. E. O. W.

1098. *Use of Duddell's Musical Arc for Measuring Small Self-inductances.* **P. Janet.** (Comptes Rendus, 134. pp. 462–463, Feb. 24, 1902.)—When a condenser of capacity C in series with a self-induction L is put as a shunt on a continuous-current arc, under certain conditions of regulation, an alternate current of periodic time $T = 2\pi\sqrt{CL}$ flows in the condenser circuit. Measure this current by means of a hot-wire ammeter, also measure the potential difference e at the terminals of the self-induction with a hot-wire voltmeter. Then, neglecting the resistance of the self-inductance as compared with its reactance, the current $I = e/L\omega$, $\omega = 2\pi/T$. Hence $L = e^2C/I^2$, thus allowing L to be calculated from purely electrical measurements.
E. C. R.

1099. *Thermo-electric Force of Nickel, Copper, and Iron.* **E. P. Harrison.** (Phil. Mag. 3. pp. 177–195, Feb., 1902.)—Two accumulators send current through 1,000 ohms and then a potentiometer wire, the thermo-couple balancing on the latter. A cadmium cell is the standard e.m.f. The Cu-Fe, Fe-Ni, and Ni-Cu were all investigated. Temperature was registered by the Callendar automatic recorder, the range being — 180° to 1,050°. Special care was taken to avoid oxidation at high temperature by having an atmosphere of hydrogen. The Ni-Cu curve differs little from a straight line, and the Cu-Fe curve differs little from a parabola ; the author gives equations to express these differences in each case. Curves and numerical tables are given for the thermoelectric forces and Peltier effect. A special set of measurements were made on the resistances of the three metals up to 1,000°. The author's results differ materially from those of Fleming and Dewar in most cases. One result is to show that the thermoelectric change in Ni-Cu coincides approximately with the resistance change. P. E. S.

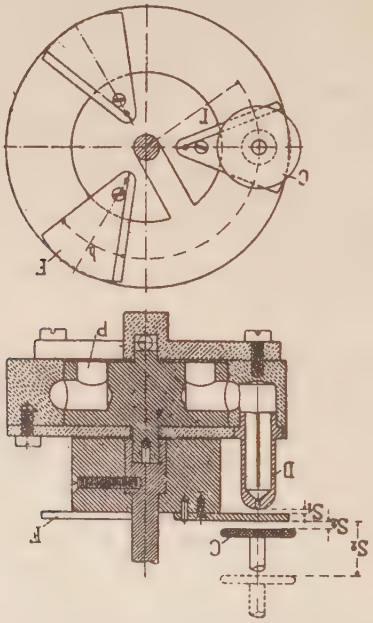
1100. *Model Illustrating Behaviour of Dielectrics.* **J. Buchanan.** (Phil. Mag. 3. pp. 240–243, Feb., 1902.)—Graphs are given of certain solutions of Fourier's equation, $dv/dt = K.d^2v/dx^2$, which are of the same form as the displacement and derived velocity curves given by Fleming and Ashton in the description of their model [see Abstract No. 2141 (1901)]. The motion of the model and the diffusion of electricity into the dielectric of a condenser are subject to the law expressed by the above equation. It is suggested that "hysteresis" diagrams might be obtained by cyclical loading of the springs.
W. E. T.

1101. *New Plug Resistance Box.* **W. Knobloch.** (Elektrotechn. Zeitschr. 23. pp. 132–133, Feb. 13, 1902.)—The author points out that in the ordinary arrangement of plug resistance boxes fifteen plugs must be inserted and two withdrawn to change from 999·9 ohms to 1,000·1 ohms, and he describes an arrangement of plug contacts with which such changes of resistance can be effected by comparatively few changes of the plugs. G. H. B.

1102. *Wehnelt Interrupter.* **A. H. Taylor.** (Phys. Rev. 14. pp. 118–121, Feb., 1902.)—The author uses carbon as the anode, in place of platinum. For a 6-in. spark coil worked directly off 100-volt supply without extra resistance in series, the best form of interrupter was one in which a carbon rod 3 mm. diameter was employed. This rod is copper-plated to within a few millimetres of the active end, and fits loosely in a glass thistle-tube, which dips into the electrolyte. The lower end of the thistle-tube is slightly drawn out on one side, and bent inwards so as to form a stop for the carbon rod. As the rod

wears away, it slides down. The object of the copper-plating is to increase the conductivity and to prevent excessive heat in the rod. The thistle-funnel fits tightly through a cork, and the cork fits the vessel containing the electrolyte. Liquid is consequently forced up the stem of the funnel, owing to the pressure of the gasses generated, until equilibrium is attained. The author uses as the electrolyte one part of potassic hydrate to four of water. For X-ray work, direct-current is recommended, but for wireless telegraphy an alternate current is preferred, because it works more evenly. R. A.

1103. *Reiniger, Gebbert, and Schall's Mercury Interrupter for Induction Coils.* (Elektrotechn. Zeitschr. 23. pp. 107–108, Feb. 6, 1902.)—In this arrangement, the mercury is pumped up through a nozzle D against the underside of a vertically adjustable contact disc C by means of a small centrifugal pump arranged in a casing P. The apparatus is mounted in a glass vessel which is

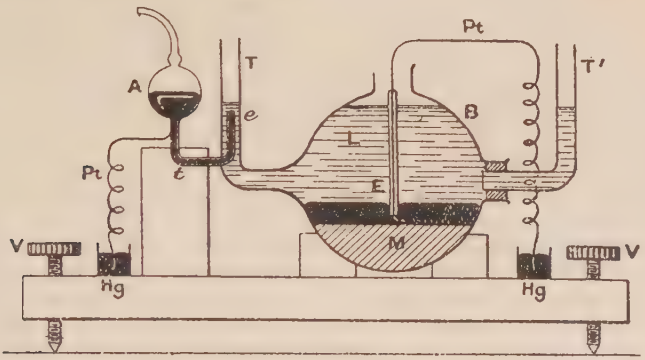


filled up to the lower edge of the nozzle D with mercury, and nearly up to the top with a spark-quenching liquid, such as alcohol or petroleum. In order to break the circuit, a series of vanes F of insulating material are mounted on the same spindle as the pump and successively cut the mercury jet. With 6 vanes, 9,000 interruptions per minute can be obtained with a 200-volt current. Formulæ are given for the length of each contact under various conditions. C. K. F.

1104. *Simple Liquid Resistance for Laboratory Use.* **R. Abegg.** (Zeitschr. Elektrochem. 8. pp. 43–44, Jan. 16, 1902.)—A short description and figure of the apparatus are given. It consists essentially of a V-tube, containing the liquid which is to be used as a resistance. One electrode is contained in the upper part of each arm of the tube, the resistance between them being varied

by raising or lowering a glass rod in the liquid. The use of a thin rod gives a delicate adjustment over a short range; with a stouter rod the adjustment is not so fine, but the range greater. If both thin and thick rods are employed, a very fine adjustment may be obtained, over a wide range, and the apparatus is suitable for use wit' liquids of very different conductivities. W. C. H.

1105. *A Capillary Electrometer.* **P. Boley.** (Comptes Rendus, 134. pp. 463-465, Feb. 24, 1902.)—Lippman's capillary electrometer cannot be worked with saturated liquid amalgams, as these are not sufficiently mobile in small capillary tubes. In order to undertake the study of the contact e.m.f's. of these amalgams, the author was led to the construction of the form of capillary electrometer shown in the accompanying illustration. The mercury (or amalgam) is contained in a pipette A, whose lower tube *t* is drawn out and



bent twice at right-angles. *t* has at its vertical extremity *e* an interior diameter of about 1 mm., it is at this spot that the meniscus forms, so that the electrometer might be called "a free-drop electrometer." The emerging drop is surrounded by the electrolyte L contained in the glass bulb B and the tubes T and T', the latter of which, being capable of turning, serve to empty the apparatus. The other electrode E has a diameter of about 12 cm., and its large surface thus renders it practically unpolarisable. Some of the first results obtained with this form of electrometer are given in the paper.

E. C. R.

1106. *Single-Contact Coherers.* **E. Branly.** (Comptes Rendus, 134. pp. 347-349, Feb. 10, 1902.)—The author describes experiments with single-contact radio-conductors, which he has found to be sensitive as well as regular in action. He has obtained good results from oxidised metal in contact with oxidised metal and from polished metal in contact with polished metal, but gives preference to oxidised metal in contact with polished metal. In one piece of apparatus three small parallel rods of the same metal are soldered at one set of extremities to a metal disc; the other ends are oxidised and rest *freely* on a plate of polished steel, giving three contacts in parallel. Conductivity was established by a very feeble spark at more than 30 m. distance, while tubes of filings were not always affected at that distance. The author obtains constant results when the small parallel rods are of iron, cast steel, rolled steel, tempered steel, aluminium, silver, copper, nickel, zinc. W. S.

ALTERNATING CURRENTS AND MAGNETISM.

1107. *The Treatment of Alternating-Current Problems by Means of Vector Diagrams.* **J. Teichmüller.** (Elektrotechn. Zeitschr. 23. pp. 1–5, Jan. 2, and pp. 30–33, Jan. 9, 1902.)—The author considers the application of vector diagrams to various alternating-current problems, with special reference to the various methods of arranging a polyphase system of conductors, and the maximum drop which can occur in unequally loaded polyphase systems.

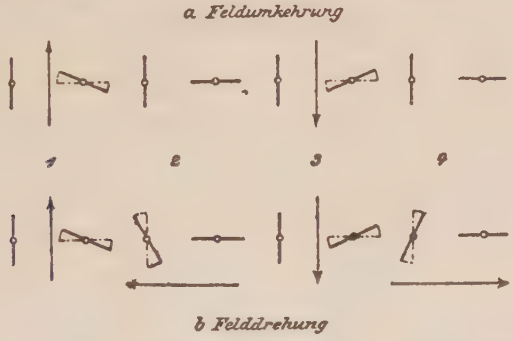
A. H.

1108. *Limitations of Graphics in Electrical Theory.* **A. Russell.** (Inst. Elect. Engin., Journ. 31. pp. 438–441, Feb., 1902.)—Any number of simple harmonic functions, to which the p.d's and currents in an alternating-current network sometimes approximate, may have their effective values and phase differences represented by vectors in a common plane, and it is very commonly assumed in dealing with alternate-current problems that the fluctuating functions which have to be considered may be so represented. The assumption of a sine law is, however, rarely justified in practice, and when this law is not followed, the representation in a plane will only lead to correct results in a few special cases. The author quotes several instances of erroneous theories obtained in this manner, and points out that many of the so-called anomalies met with in practical polyphase work, merely represent discrepancies with a graphical theory which is only applicable to simple harmonic functions, and therefore, when applied to practical problems, is only a first approximation. Two periodic functions of the same frequency may be treated in this manner, and the author shows that three such functions may be similarly represented by vectors drawn in space, but that no such representation is generally possible for four or more ; for example, if one were a constant, it would have to be represented by a vector perpendicular to each of the three others, which is impossible if these form a solid angle.

G. W. DE T.

1109. *Permeameter for Testing Materials in Bulk.* **C. V. Drysdale.** (Inst. Elect. Engin., Journ. 31. pp. 283–306 ; Discussion, pp. 306–320, Feb., 1902.)—An instrument capable of testing the magnetic qualities of large or small castings or forgings without the preparation of test pieces has been designed. A drill of special form is employed, which cuts a circular hole with a conical top in the specimen, but leaving a pin in the centre. The hole is usually $\frac{3}{8}$ in. diameter and $\frac{5}{8}$ in. deep, and the diameter of the pin is $\frac{1}{10}$ of an inch. The testing arrangement consists simply of a soft iron plug carrying a bobbin, on which are wound two circuits, a magnetising and a search coil. The plug is split, and turned slightly conical on its outside surface, while the drill cuts the cone of the same angle as that of the plug. Hence, on drilling the hole and inserting the plug, a miniature permeameter is produced. In the event of it not being allowable to bore a hole of such a size, it is proposed to leave a boss on the casting in any convenient place, and which could be subsequently cut off. The readings may be taken by three methods, which are described, but the author prefers the simple ballistic test, and he has arranged two commercial forms of apparatus suitable. One type allows the permeability and retentivity to be directly read off, the other enables the magnetisation curve and the B-H cycle to be plotted. The accuracy ordinarily obtained is sufficient for all engineering purposes. In the discussion, the general opinion was that the instrument was a very practical one, and would prove of great service to dynamo manufacturers. W. W. H. G.

1110. *Hysteresis in a Rotating Field.* **R. Hiecke.** (Elektrotechn. Zeitschr. 23. pp. 142–143, Feb. 13, 1902.)—Referring to Dina's paper [see Abstracts Nos. 2050 (1900) and 85 (1902)], the author points out that the conditions of Dina's experiments corresponded more nearly to an alternating than to a rotating field, and hence some of his results are untrustworthy. Thus, Dina finds the hysteresis in a rotating field to be for low inductions only slightly greater than that in an alternating one, whereas the author and A. Grau found that the rotating hysteresis is almost exactly double the alternating one. This latter result is easily accounted for by the molecular theory. For if we



consider two groups of molecules at right-angles to each other, and apply a weak alternating field, then, as shown by the upper row of diagrams, only one group of molecules will oscillate through a certain angle about their mean position. But a weak rotating field will—as shown by the lower row—cause *all* the molecules to oscillate through the same angle. The author further shows that, according to the molecular theory, the maximum value of rotating hysteresis should occur at a value of the intensity of magnetisation $= \frac{2}{\pi}$ times the maximum magnetisation. This result is fully confirmed by experiment. A. H.

1111. *Electromagnets.* **F. R. Dietze.** (Elektrotechn. Zeitschr. 23. pp. 131–132, Feb. 13, 1902. Paper read before the Ninth Annual Meeting of the Verband Deutscher Elektrotechniker in Dresden.)—The article describes various types of electromagnets for lifting or other purposes. The author distinguishes between "core-magnets" and "mantle-magnets." In the former the armature moves outside the coils, or is drawn into them; in the latter the armature lies within the coil, which is surrounded by iron. The mantel type of magnet has the advantages of a very small stray field, a well-protected coil, and facility in adapting an air dash-pot.

A ring-magnet is described, with diametral armature to give a turning movement. Figures are given of the pull obtainable from different types of magnets, but the data are incomplete. G. H. B.

1112. *Contact Magnetising Action.* **C. Maurain.** (Journ. de Physique, 1. pp. 90–100, Feb., 1902.)—The author describes experiments made with a view to the further elucidation of the magnetising action of iron deposited in a magnetic field. In the first series of experiments a brass rod is coated with iron by electrolytic deposition in a certain magnetic field, the deposit

assuming a definite magnetisation ; then the field is suddenly changed, either to zero or to some other value. When the field is simply suppressed the layers of iron deposited afterwards have an intensity of magnetisation almost as great as that of the initial layers ; thus with initial fields of 15 and 1·8 gausses, the magnetisation of the new layers is 0·85 and 0·87, respectively, of that of the initial layers. When the sign of the field is changed the action of the initial layers on the new ones is much stronger than that of the new field, as may be seen from the following numbers, H and H′ representing the strengths of the initial and final fields respectively :—

		Intensity of Magnetisation.	
H.	H′.	Initial Layers.	New Layers.
+ 9·5	— 1·5	+ 3·6	+ 3
+ 9·5	— 8·5	+ 3·5	+ 2·6
+ 15	— 15	+ 17	+ 7

If the field is made more strongly negative a disturbing factor comes into play, the magnetisation of the initial layers being suddenly changed from a + to a — value. In studying the effect of distance on the magnetising action, layers of various thicknesses of non-magnetic metals—gold, silver, or copper—are placed between the magnetised kathode and the deposit of iron on which it acts. The results of the experiments here described are expressed in the form of curves, having for ordinates the magnetometer deflections, and for abscissæ the time during which deposition goes on in the negative field, the initial deposit being positively magnetised. For the sake of comparison the corresponding curve for the case when no non-magnetic metal is interposed is also given. The general character of the results obtained may be understood from the curves obtained with gold as the intermediate metal. When no gold is used the curve is of course a straight line, having a certain slope representing the intensity of magnetisation ; with a deposit of gold 19.8×10^{-6} mm. in thickness the slope of the curve is lessened considerably, and this is more and more the case as the thickness increases, the curves bending over and passing through the axis of abscissæ ; with the thicker layers of gold, such as 136×10^{-6} mm., the magnetometer shows a negative deflection immediately the second deposit of iron is commenced. For copper and gold the corresponding thicknesses required to give equal effects on the magnetisation are about the same, but for silver greater thicknesses appear to be necessary, but great difficulty was met with in obtaining regular deposits of this metal. [See also Abstracts Nos. 2235 (1900) and 392 (1901).] T. H. P.

1113. *Motion of Electrolytes in a Magnetic Field.* **P. Drude.** (Zeitschr. Elektrochem. 8. pp. 65–67, Jan. 30, 1902.)—The experiment described by O. Urbasch [see Abstract No. 107 (1901)] could in no case succeed unless there were an electric current in the electrolytes, as by both of them being in contact with the same metal, and in Urbasch's experiment this was the case. A. D.

1114. *Hall Effect in Gases at Low Pressures.* **H. A. Wilson.** (Cambridge Phil. Soc., Proc. 11. pp. 249–263, Feb., 1902.)—A very large Hall effect is found in the positive column of the ordinary electric discharge in gases at low pressures, the electrodes being immersed in an apparently uniform positive column produced by a sensibly steady current. The application of the magnetic field always produces a transverse motion of the positive column,

so that it becomes brighter along one side of the tube than along the other, the shift being in the direction in which a flexible conductor carrying a current moves. The Hall effect is proportional to the magnetic field, is probably nearly independent of the current at pressures down to 0·26 mm., and varies inversely as the pressure. If the influence of the walls of the discharge tube be neglected, Larmor's theory for completely dissociated salt solutions (Æther and Matter, p. 301) applies without modification to the uniform positive column. The walls of the tube and the electrodes do no doubt absorb charges, but these are, especially when the currents used are very small, too small to influence the measurements made. The actual difference between the velocities of the negative and positive ions in the positive column is $4{\cdot}95 \times 10^8/p$, where p is the pressure in millimetres of mercury. A. D.

1115. *The Electron Hypothesis and Theory of Magnetism.* **W. Voigt.** (Gesell. Wiss. Göttingen, Nachr. Math.-Phys. Klasse, 3. pp. 169–200, 1901.)—This paper consists of an analytical investigation of the possibility of obtaining from the theory of electrons an explanation of paramagnetic and diamagnetic phenomena. It is assumed that the translation velocities of the electrons are small in comparison with the velocity of radiation; and, on this assumption, some important conclusions are arrived at.

It is assumed in the first place, in accordance with the analogy of the unresisted molecular currents of the older magnetic theories, that the electronic motions are undamped, and it is then found that changes in the velocities of the electrons in consequence of the formation of magnetic fields will not give rise to magnetic phenomena. The effects of damping, which play so important a part in the optical phenomena of dispersion, are then considered, and the author shows that if the electronic motions of a body in a constant magnetic field are subject to damping, while at the same time the energy dissipated is supplied by means of any completely irregular series of impacts, as, for example, with other electrons, or with ponderable molecules, so that the mean value of the energy tends to a fixed limit, the body will exhibit paramagnetic or diamagnetic properties, according to whether the mean energy of the electrons after the impacts is mainly potential or mainly kinetic. Finally it is shown that the presence in a magnetic field of rotating bodies carrying electric charges can only give rise to diamagnetic phenomena when they experience no resistance. Charged bodies, on the other hand, rotating against resistance and having their energy loss made up by means of irregular impacts, may give rise to either paramagnetic or diamagnetic phenomena. G. W. DE T.

ELECTROPHYSIOLOGY AND ELECTROTHERAPEUTICS.

1116. *The Effect of Electric Waves on the Human Brain.* **A. F. Collins.** (Elect. World and Engineer, 39. pp. 335–338, Feb. 22, 1902.)—The author traces a connection between atmospheric electrical disturbances and their effect upon human beings by supposing a coherer-action of the brain tissues. He describes experiments with fresh brain substance which seem to show that variations in resistance, like those of a coherer, can be obtained with conductors embedded in fresh brain tissue. L. J.

1117. *High-Frequency Currents for Producing Analgesia in Dentistry.* **L. R. Régnier** and **H. Didsbury.** (Comptes Rendus, 134. pp. 373–375, Feb. 10, 1902.)—The authors advise the employment of currents of high

frequency and high potential to take the place of anæsthetics in operations on the teeth. A d'Arsonval or Tesla apparatus with Oudin's resonator attached is used. One pole is connected to an electrode, moulded to fit the tooth, and lined with wet asbestos to counteract any heating effect on the tooth itself. Five minutes suffices to render insensible a tooth with a single fang. Molar teeth and those with several fangs require longer. If there is periostitis or inflammation of the root the process is less successful, and further study of these is called for. L. J.

1118. *Electricity and Plant Life.* **V. G. Heber.** (West. Electn. 30. p. 59, Jan. 25, 1902.)—This paper describes experiments showing the beneficial effect of passing a continuous or intermittent electrical current during the night, reversing the current every third or sixth day, and keeping the soil damp. A. D.

1119. *Lead Poisoning in a Child from the Use of a Pewter Mug.* **Variot.** (Revue Int. d'Électrothérapie, 11. pp. 259–264, Sept.–Oct., 1901.)—The author reports a case of extensive paralysis of the limbs in a child of four and a half years. The characteristic blue line seen upon its gums indicated the probability that the symptoms were due to lead. A search revealed no source of lead except a pewter cup which was used habitually by the child. This contained 75 per cent. of lead. The same cup had been used by an elder child at a former period, and this child also showed the blue line of lead upon her gums, although she had never had any paralytic symptoms. For comparison the pewter mugs used at the children's hospitals in Paris were analysed and found to contain 12·7 per cent. of lead. L. J.

REFERENCES.

1120. *Laws of Electric Energy.* **E. Carvallo.** (Comptes Rendus, 133. pp. 1195–1197, Dec. 23, 1901.)

1121. *Application of Lagrange's Equations to Electrodynamics.* **Liénard.** (Comptes Rendus, 134. pp. 163–165, Jan. 20, 1902.)—This is a paper pointing out a fallacy in Carvallo's argument against the general applicability of Lagrange's equations to electrodynamics. [See Abstracts Nos. 342 and 1120 (1902).] G. W. DE T.

1122. *Kelvin's Electric Measuring Instruments.* **M. Maclean.** (Inst. Elect. Engin., Journ. 31. pp. 117–137, Dec., 1901.)—The paper gives a brief description, with illustrations, of Kelvin's ammeters, voltmeters, and wattmeters. G. H. B.

1123. *Reflexion of Kathode Rays.* **J. Stark.** (Phys. Zeitschr. 3. pp. 161–165, Jan. 15, 1902.)—The paper is purely theoretical. It deals with the reflexion of kathode rays on the basis of the ionic theory. R. S. W.

1124. *Magnetokinetic Top.* **H. du Bois.** (Archives Néerlandaises, 6. pp. 581–592, 1901.)—This paper contains preliminary mathematical and quantitative work in pursuance of the investigation already qualitatively dealt with. [See Abstract No. 875 (1901).] A. D.

1125. *Magnetic Observations in South-East China.* **F. S. Chevalier.** (Terrestrial Magnetism, 6. p. 186, Dec., 1901).

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1126. *Atomic Weight of Uranium.* **T. W. Richards** and **B. S. Merigold.** (Amer. Acad., Proc. 37. pp. 365–395, Feb., 1902.)—In the "less inaccurate" previous work the results varied from 238 to 240. Zimmermann's mean determination of 239·6, from the oxidation of UO_2 to U_3O_8 is affected by the difficulty always experienced in forming a more from a less voluminous solid (sp. gr. UO_2 10·2, U_3O_8 7·3). Richards has previously investigated the errors caused by occlusion [see Abstract No. 593 (1899)], and has pointed out that reduction is usually much more complete than oxidation. As to Aloy's average, 239·40 [see Abstract No. 97 (1902)], from the ratio between the amounts of uranous oxide and of nitrogen gas obtained by heating uranyl nitrate and afterwards reducing in hydrogen, it is shown that the method is open to many inaccuracies. The author's work of four years, using the chlorides, bromide, iodate, and oxalate, is described, and details are given of their new determinations from the ratios $UBr_4 : 4AgBr$ and $UBr_4 : 4Ag$ The uranous bromide is prepared in a special subliming and bottling apparatus (figured), which is valuable for general purposes. At the high temperature bromine vapour attacks the porcelain tube, giving a little NaBr which has to be determined and allowed for. After oxidation by H_2O_2 the bromine was precipitated by silver nitrate in orange light, the exact end point being ascertained by means of the *nephelometer* (Amer. Acad. Proc., 30. 385, 1894). The original material was prepared by methods which have been shown by Crookes (Proc. Roy. Soc., 66. 409, 1900) to remove radio-active substance from uranium. Full details are given of the purification of the other substances used. As the mean value obtained, 238·53, is lower than has been previously accepted, several causes which might tend to lower it are discussed and dismissed, therefore "if oxygen is taken as 16·000, and bromine as 79·555, the atomic weight of uranium appears to be not far from 238·53." S. R.

1127. *Determination of the Molecular Weight of Liquids.* **A. Kistiakowsky.** (Jurn. Russk. Fisik. Chimicesk, Obscestva, 34. 1a. pp. 70–90, 1902.)—The Eötvös-Ramsay method of basing the determination of molecular weights on surface-tension measurements has so far been seldom made use of. The author suggests some simplifications of Ramsay's formulæ, testing them by calculating a large number of molecular weights from the data of other experimenters, the agreement with the theoretical values being fairly satisfactory. He next goes on to show a possible connection of these formulæ with Guldberg's views, the resulting law being as follows: Non-associated liquids, taken at their respective boiling-points, will exhibit approximately the same capillary energy. It is pointed out that this rule may, as well as Ramsay's formulæ, serve to ascertain whether a given liquid is in a state of association or not, though the series of hydrocarbons $C_6H_{2(n-x)}$ presents some striking exceptions. The author finally proceeds to make some measurements, especially on some terms of the above series, in order to test those deviations; it is suggested that these hydrocarbons may not represent chemical individuals, an hypothesis in favour of which, in some cases, chemical instances may be adduced. A. G.

1128. *Blue and Green Modifications of Sulphur.* **N. Orloff.** (Jurn. Russk. Fisik. Chimicesk. Obscestva, 34. 1a. pp. 52–67, 1902.)—The author draws the following conclusions from his own researches in connection with the work done by previous experimenters : (1) There are many reasons for presuming the existence of a particular modification of sulphur of a blue or green colour, the latter being possibly a mixture of the former with particles of yellow sulphur. This modification proves most unstable, and capable of existing only by means of a special kind of fixation on chlorides at the very moment of its being evolved from compounds, as well as in certain other inorganic and possibly organic compounds. (2) Among the circumstances favourable to the formation of this modification of sulphur, there is first of all the influence of dissociation and of rather incomplete reactions : the experiments of K. Gil on polysulphides of ammonium and alcohol, as well as on acetone, are quoted, those of Nöllner, and particularly Günther's researches with soldered tubes are mentioned, the latter ones promising to give interesting results on being repeated from the standpoint of the phase-rule. (3) As to the constitution of the molecule of blue sulphur, definite conclusions cannot, so far, be drawn ; experiments with CdS and S_2Cl_2, however, in connection with Günther's investigations and with the colour of the body, would suggest that this molecule may be of an ozonic character, *i.e.*, built up of three atoms. It seems as though the preparation of the body in question should meet with similar difficulties as that of ozone. A. G.

1129. *Expansion of a Mixture of Hydrogen and Chlorine under the Influence of Light.* **P. V. Bevan.** (Cambridge Phil. Soc., Proc. 11. pp. 264–266, Feb., 1902.)—The initial expansion of a mixture of hydrogen and chlorine when exposed to light was observed by Draper, and attributed by Pringsheim to dissociation of hydrogen and chlorine molecules. The author, using Roscoe's apparatus (Phil. Trans., 1857, p. 359), decides that the phenomenon occurs only when there is combination of H and Cl, and is due to the heat evolved by that combination. D. H. J.

1130. *Influence of Sunlight on the Bromination of the Higher Methyl Benzenes.* **A. Korczynski.** (Accad. Sci. Cracovie, Bull. 1. pp. 14–18, Jan., 1902.)—The influence of sunlight in promoting substitution of bromine for hydrogen in the side chains is not manifest with the higher methyl benzenes. Thus hexamethylbenzene is not attacked at all under its influence, while pentamethyl benzene and durene give (at the ordinary temperature) ring-substitution products. When durene is *heated* with bromine, the latter enters the side chain ; with pentamethyl benzene, under similar circumstances, the bromine enters the ring. The heating of hexamethyl benzene with bromine in a sealed tube leads to the production of hexabrom-hexamethyl benzene. D. H. J.

1131. *Solubility of Zinc Hydroxide in Ammonia and Ammonium Bases.* **W. Herz.** (Zeitschr. Anorg. Chem. 30. 2. pp. 280–282, 1902.)—Previous researches of the author have dealt with equilibrium phenomena and quantitative precipitation of zinc. In connection herewith some experiments on the solubility of $Zn(OH)_2$ in ammoniac and ammonium bases were made, the main result being that to dissolve dried zinc oxide the number of basic molecules required will be greater as the base is more dilute. By substituting in the ammonia molecule one hydrogen atom by organic radicals the solubility will be diminished, the more so the higher the molecular weight of the substitute. Di-substituted amines will not dissolve zinc hydroxide. A. G.

1132. *Influence of Hydrochloric Acid upon Precipitation of Cuprous Sulphocyanide.* **R. G. van Name.** (Zeitschr. Anorg. Chem. 30. 1. pp. 122–130, 1902.)—The author, some time ago, recorded some researches on determination of copper by means of precipitation as cuprous sulphocyanide. As, however, in the discussion of the results, no distinction was made between free acid originally present and that remaining in solution on adding the precipitant, new measurements have proved necessary. In presence of free hydrochloric acid the precipitation of cuprous rhodanide by a slight excess of ammonium rhodanide is found to be imperfect, losses, however, not being considered, as long as the quantity of concentrated acid does not exceed 0·5 per cent. of the total volume. A practically perfect precipitation in presence of a considerable amount of acid can under certain circumstances be obtained by adding a considerable excess of ammonium rhodanide. The effect of adding larger quantities of ammonium bisulphite in presence of hydrochloric acid is very much the same as that of a partial neutralisation by means of ammonia, the acid forming ammonium chloride. If the amount of free acid remaining on adding the bisulphide be not too large, the ammonium chloride does not prevent the precipitation being complete. If the quantity of acid present be very large, it is advisable to take away most of it before precipitating the copper. A. G.

1133. *Avidity of Phenol.* **J. S. Plotnikow.** (Zeitschr. Elektrochem. 8. p. 73, Jan. 30, 1902.)—The author determines the avidity of phenol by the temperature changes which take place on the mixture of gram-equivalents of sodium sulphate and phenol ; this was found to give rise to the absorption of 225 small calories. The results indicate that phenol is considerably weaker than acetic acid, and somewhat stronger than boric acid. From previous observations on the hydrolysis of potassium phenolate (Shields, Zeitschr. f. Phys. Chem. 12. 175) and from measurements of conductivity (Walker, Zeitschr. f. Phys. Chem. 32. 137), phenol was found to be considerably weaker than boric acid, and a little stronger than carbonic acid.
W. C. B.

1134. *Absorbents of Water.* **W. J. Busnikow.** (Zeitschr. Elektrochem. 8. pp. 72–73, Jan. 30, 1902.)—The author investigates the absorption of water by various bodies, by placing a weighed amount of the substance—for instance, sulphuric acid—in a glass vessel, over water in a dessicator. The increase in weight is divided by the number of hours between successive weighings. The quotient obtained is found neither to be constant nor to decrease constantly. The author supposes that the irregularities are due to the formation of hydrates. Many other substances were investigated in a similar manner, *e.g.*, $MgCl_2$, NaCl, Na_2CO_3. The abstract of the paper contains an unfavourable criticism of the author's experiments and conclusions.
W. C. B.

1135. *Catalysis.* **D. Turbaba.** (Zeitschr. Elektrochem. 8. pp. 70–71, Jan. 30, 1902.)—The author had already shown, in 1888, that the vapour of pure paraldehyde is not changed into aldehyde to any measurable extent, by continued heating to temperatures between 100° C. and 168° C. Kekulé and others have shown that the change takes place fairly rapidly in presence of certain substances ; moreover it has been proved that those substances which bring about the change from paraldehyde to aldehyde at high temperatures also cause the opposite reaction, the polymerisation of aldehyde to

paraldehyde, at lower temperatures. Bodies which show this behaviour include : HCl, HNO_3, H_2SO_4, $COCl_2$, SO_2, $ZnCl_2$, $CaCl_2$, $HgBr_2$, $HgCl_2$, B_2O_3, and $B(OH)_3$. These observations afforded the basis for a further research on Ostwald's theorem, that the presence of a catalyst does not affect the equilibrium-conditions of a reversible reaction. The research was made by means of dilatometers, kept at a constant temperature of 50·5° C. in an Ostwald thermostat. For the determination of the influence of various catalysts on the equilibrium between aldehyde and paraldehyde the author started with pure paraldehyde, to which varying masses of the different bodies were added, and the volume changes noted. With SO_2, $ZnSO_4$, HCl, oxalic acid, and H_3PO_4, the mean maximum increase was 8·19 per cent. of the original volume (variations between 8·10 and 8·34). With H^2SO_4, CCl_3COOH, $CdCl_2$, B_2O_3, $HgCl_2$, $ZnCl_2$, $CuSO_4$, and $CdSO_4$, the maximum was about 8·3 per cent. The author draws the conclusion in accordance with the above theory, that the equilibrium conditions are not influenced by the nature and mass of the catalyst present. There is equilibrium between aldehyde and paraldehyde in the liquid state, when the proportion of aldehyde lies between 33·36 per cent. and 35·23 per cent. In a second part of the research the author deals with the equilibrium between the two substances in various solvents—for instance water, acetone, and toluene. He finds that both the solvent used and the concentration affect the equilibrium to a large extent. With increasing dilution the equilibrium point is moved in the direction of a larger proportion of aldehyde, and the dissociating power of the solvent increases with its dielectric constant. Tables of data are given, and from these the author constructs an equilibrium formula $(1-X)/V = KX^3/V^3$, where V = volume of the solution and $1-X$ the mass of undecomposed paraldehyde ; values of K are given for water, acetone, and toluene. The author also finds that the accelerative action of various acids on the dissociation of paraldehyde in aqueous solution is approximately proportional to the concentration of their hydrogen ions. In the following table (1) is the conductivity of normal solutions of the acids, (2) influence on catalysis of methyl acetate, (3) inversion of cane-sugar, (4) splitting up of paraldehyde—

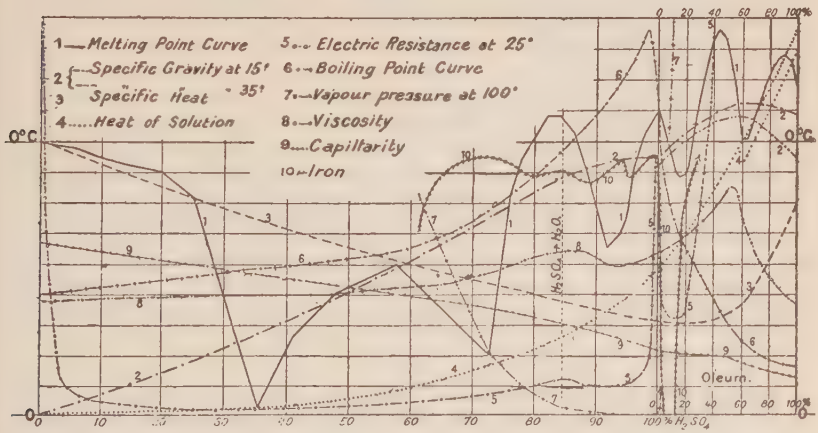
Acids.	1	2	3	4
HCl	100	100	100	100
CCl_3COOH	62·3	68·2	75·4	85·0
H_2SO_4	65·1	73·9	53·6	54·0
COOH.COOH	19·7	17·6	18·6	26·6
$CH_2Cl.COOH$	4·9	4·3	4·8	8·6

W. C. B.

1136. *True Density of Chemical Compounds.* **J. J. Kanonnikow.** (Zeitschr. Elektrochem. 8. pp. 69–70. Jan. 30, 1902.)—Part I. Hydrocarbons.—The true density of a body is the mass of that body which occupies a volume of 1 c.cm., when the molecules (considered as spheres) are brought into contact. In Lorentz and Lorenz's formula $R = (N^2-1)/(N^2+2)\cdot\frac{1}{d}$. N represents the index of refraction for rays of infinite wave-length, and R denotes both the specific refraction for these rays and also the real specific volume of the molecule. (Nernst, Theoretical Chemistry.) The reciprocal value $D = \frac{1}{R}$ represents the true density, and the number obtained by multiplying D by M, the molecular weight, is within fairly wide limits independent of the state of

aggregation and the temperature. The value MD is especially suitable for throwing light on the structure of compounds owing to its constitutive character. The molecular density of a hydrocarbon $CnH_{Zn \pm m}$ can be obtained from the formula $MD = nc + (Zn \pm m)h + x\alpha + y\beta + z\gamma + v\delta - 3{\cdot}87$ where x = the number of double linkages, y of triple, z of rings, and v of "naphthalene' linkages. The value of MD for carbon as diamond is 67 ; for combined carbon (c in above equation) = 39·7. Hydrogen (h in above equation) 0·907 $\alpha = -5{\cdot}8$; $\beta = -3{\cdot}87$; $\gamma = +8{\cdot}7$; $\delta = -25{\cdot}14$. The value 3·87 is a constant representing the substitution of H in methane by CH_2. The formula is supported by many examples, and the differences from theory are less than 1 per cent. For benzene and its derivatives the results point to Kekulé's formula. Part II. Oxygen Compounds. — Although the values obtained for the true density are concordant for the hydrocarbons, those found for oxygen compounds show many irregularities. Firstly, the influence of the oxygen depends on its state of combination, whether as hydroxyl, carboxyl, or in ethereal combination ; secondly, there are still irregularities which may depend either on polymerisation or the presence of tetrad oxygen. Finally tautomeric forms must be frequently assumed. These assumptions rob the results of much of their value ; in some cases hexad oxygen must be present in order to reconcile the discrepancies found. W. C. B.

1137. *Physical Chemistry of Sulphuric and Fuming Sulphuric Acids.* **O. Sackur.** (Zeitschr. Elektrochem. 8. pp. 77–82, Feb. 6, 1902.)—The introduction of the contact method for the manufacture of sulphuric acid has led to fresh work on the physical properties of sulphuric acid. In the present paper the writer discusses this new work, of which a conception may be obtained from the following diagram :—



The writer considers the results from the point of view that we are not dealing here with simple solutions of H_2SO_4 in water, but rather with solutions in which there is more or less dissociation and hydration according to an equation such as $2H_2SO_4 \rightleftarrows H_2SO_4.H_2O + SO_3$. D. H. J.

1138. *The Critical State.* **J. J. Kanonnikow.** (Zeitschr. Elektrochem. 8. p. 70, Jan. 30, 1902.)—From considerations connected with the "true

densities" of bodies [see Abstracts Nos. 931 and 932 (1902)] the author draws the conclusion that the equation for critical volume should be $\phi = 2b$, and not, as according to van der Waals, $\phi = 3b$. Further assuming Lorentz and Lorenz's formula for refractive power $r = (n^2 - 1)/(n^2 + 2)$, then $b = rd\sqrt{2}$ where d is the density. In order to obtain results agreeing with this formula, the author assumes the existence of tetrad oxygen and hexad carbon. From calculations made with the above formula, substances possess the same constitutional formulæ at the critical point as in dilute solution. W. C. B.

1139. *Neutralisation of Phosphoric Acid.* **Berthelot.** (Annal. Chim. Phys. 25. pp. 145–153, Feb., 1902.)—When increasing quantities of lime water are added to a solution of phosphoric acid, a precipitate of the composition $CaHPO_4$ is formed when one hydrogen atom of the acid has been neutralised and when two molecular proportions of lime are present to one of the acid, the latter is almost completely precipitated. On continuing the addition of lime the latter is gradually absorbed by the precipitate with the formation of a compound containing 4CaO to every P_2O_5; this absorption of lime is very slow, even when large proportions of the base are present. It is noteworthy that a natural calcium phosphate, isoclase, occurs in which the relation of base to acid is $4CaO : P_2O_5$. When lime is added to phosphoric acid in presence of methyl orange, the colour of the latter changes when monocalcium phosphate, CaO, P_2O_5, is formed. If, on the other hand, the acid be added to the lime, the colour change of the indicator occurs when the composition is $2CaO, P_2O_5$. In the double decomposition between alkali phosphates and calcium salts, the precipitate does not in all cases consist always of the tricalcium salt, but sometimes of the dicalcium compound; whilst, when barium salts are employed, a double salt of the composition, P_2O_5, 2BaO, 2NaOH, is formed. The basic salts obtained by the action of lime water on dicalcium phosphate do not separate well from the solution, but can be made to do so either by the addition of sodium chloride or by heating. T. H. P.

1140. *Reactions of Two Bases Mixed with Phosphoric Acid.* **Berthelot.** (Annal. Chim. Phys. 25. pp. 153–163, Feb., 1902.)—The simultaneous action of lime (or baryta) and soda on phosphoric acid under varying conditions has been investigated. When the proportions of the mixture are represented by $2H_3PO_4 + 4NaOH + CaO$, the precipitate formed has approximately the composition $(PO_4)_4\,Ca_3Na_6$, a similar compound being obtained when baryta is used in place of lime. Also for the mixture, $2H_3PO_4 + CaO$ (or BaO) + 2NaOH, double as much phosphoric acid is precipitated as would correspond with the formation of $Ca_3(PO_4)_2$, and the precipitate is found to contain sodium. T. H. P.

1141. *Formation of Insoluble Phosphates by Double Decomposition.* **Berthelot.** (Annal. Chim. Phys. 25. pp. 164–176, Feb., 1902.)—When one molecular proportion of disodium phosphate is mixed in the cold with three of silver nitrate, all the silver present is precipitated. The acidity of the filtrate towards phenolphthaleïn and methyl orange indicates the formation of 1 mol. of the primary sodium phosphate from 2 mols. of the secondary. The precipitate does not, however, consist entirely of pure trisilver phosphate, but contains a small quantity of the disodium salt which is only very slowly and imperfectly removed by washing. When 1 mol. of disodium phosphate and 2 mols. of silver nitrate are mixed in solution, one-sixth of the silver remains

dissolved as primary phosphate, together with free phosphoric acid and sodium nitrate; the precipitate consists mainly of trisilver phosphate, but retains sodium phosphate. The author considers that the sodium phosphate which occurs admixed with the precipitated silver phosphate is present in the form of a double salt, and that in chemical equilibria of this type such double salts must play a part. T. H. P.

1142. *Chemical Equilibria between Phosphoric Acid and Chlorides of the Alkaline Earth Metals.* **Berthelot.** (Annal. Chim. Phys. 25. pp. 176–196, Feb., 1902.)—The author describes a number of experiments in which he has determined the alkalinity or acidity of mixtures, both with and without the addition of various proportions of sodium hydroxide, of (1) phosphoric acid and alkaline earth chlorides, and of (2) mono- and di-sodium phosphates and chlorides of the alkaline earth metals. Exact neutrality is seldom obtained with the proportions of the reacting substances corresponding with simple equations. In some cases the attainment of equilibrium requires time, whilst in others the result obtained varies with the time during which the precipitated phosphate remains in contact with the liquid. The amount of alkaline earth required to neutralise 1 mol. of phosphoric acid varies, according to the conditions, from 2 to 4 equivalents. T. H. P.

1143. *Heterogeneous Equilibrium between Mixed Crystals of Isomorphous Saline Hydrates.* **G. Bruni** and **W. Meyerhoffer.** (Accad. Lincei, Atti, 11. pp. 185–190, Feb. 16, 1902.)—One of the authors [G. Bruni; *cf.* Abstract No. 2423 (1901)] has already given a general theoretical treatment of the different types of heterogeneous equilibrium. In the present paper, with a view to the early publication of experimental data, the authors consider the special case of mixtures of two isomorphous substances A and B, which, when dissolved in water, give, each, one or two hydrates, $A + x.H_2O$, $A + y.H_2O$, $B + x.H_2O$, $B + y.H_2O$, where x is $> y$, of which those of corresponding composition are also isomorphous. The two hydrates rich in water (with $x H_2O$) will pass into those poorer in water (with $y H_2O$) at definite temperatures T_A and T_B, and the temperatures of transformation of the mixed crystals with $x.H_2O$ will depend on the composition of these. For equilibrium we have four phases, viz., mixed crystals with $x.H_2O$ and with $y.H_2O$, solution and vapour—which for a system of three components constitutes a series of non-variant systems without any multiple point. The curve to express the change of composition of the $x.H_2O$ crystals with change of temperature will, therefore, be a continuous one. We may consider the relation between the mixed crystals with $x H_2O$ and those with $y.H_2O$, by applying a theorem of Gibbs, according to which, at each temperature that system is stable for which the function ζ is a minimum. It will be found that (*a*) the more hydrated crystals contain in greater proportion than those less hydrated, that component of which the transformation temperature is higher. (*b*) The crystals more hydrated contain in greater proportion than those less hydrated, that component which, when added to the system, raises the temperature of transformation. D. H. J.

1144. *Chemical Equilibria between the Ammonium Phosphates and Barium Chloride.* **Berthelot.** (Annal. Chim. Phys. 25. pp. 197–200, Feb., 1902.)—In a manner similar to that described in Abstract No. 1142 (1902) the author has examined the behaviour of three ammonium phosphates towards barium chloride. The results given are, however, not very accurate, owing to the dissociation of the ammonium phosphates. T. H. P.

1145. *Chemical Equilibria between the Ammonium Phosphates and Magnesium Chloride.* **Berthelot.** (Annal. Chim. Phys. 25. pp. 200–204, Feb., 1902.)—Investigation of the reactions between phosphoric acid, ammonia and magnesium chloride shows that the equilibrium is very complicated, and also depends in a very high degree on the conditions under which the compounds are mixed. T. H. P.

1146. *New Measurements on Absorption.* **W. Müller-Erzbach.** (Deutsch. Phys. Gesell., Verh. 4. 3. pp. 35–38, Feb. 7, 1902.)—Measurements on the absorption of the vapours of water and carbon disulphide by aluminia or ferric oxides. The novelty consists in keeping the absorbing substance at a slightly higher temperature than the liquid which is emitting the vapour, so that condensation due to cooling is avoided. It is found that water vapour can drive our previously absorbed carbon disulphide, while the latter is scarcely at all absorbed if the substance has previously taken up its full complement of water vapour. The latter is much more strongly held. In fact, if the substance has been only partially saturated with water, it can take up some carbon disulphide, but the latter appears only to form an external layer, and can be again driven out without the absorbed water being affected (except to a very slight degree). The author considers that his measurements point to a much greater value for the radius of the sphere of molecular attraction than that usually assumed. F. G. D.

1147. *Equation for the Osmotic Pressure of Concentrated Solutions.* **C. H. Wind.** (Archives Néerlandaises, 6. pp. 714–726, 1901.)—The author bases his theory, like that of van der Waals, on the virial equation, and arrives, by a process of reasoning which is too long for reproduction, at an equation of the form—

$$\left(N + \frac{a - a'}{V^2}\right)\left(V - \theta\frac{b^2}{V}\right) = RT$$

where N = osmotic pressure ;
V = volume of solution containing one grm. mol. solute ;
b = actual volume occupied by solute ;
a, a', θ = constants.

This equation, compared with the equation of van der Waals, present two novelties. In the first place the term $\frac{a - a'}{V^2}$ may be *negative*, and secondly the term $\theta\frac{b^2}{V}$, as it contains the volume V in the denominator, only becomes appreciable for small volumes. The author tests his equation by means of data collected for concentrated cane-sugar solutions by Ewan [see Abstract No. 674 (1900)] and also by means of measurements of the e.m.f. of cells of the type Cd-amalgam 1 — $CdSO_4$ solution — Cd-amalgam 2 carried out by H. G. Bijl in his thesis for the Doctorate (Amsterdam, 1901). In both cases it is found that the equation reproduces the experimental results with great accuracy. This test only means that an equation of the *form* given can be employed to reproduce the experimental results, for the values of $a - a'$ and θb^2 are obtained by calculation from two of the experimental numbers. F. G. D.

1148. *Lead-Tellurium Alloys.* **Fay** and **Gillson.** (Zeitschr. Elektrochem. 8. p. 54, Jan. 23, 1902.)—After the separation of copper and silver from the Colorado copper-ore, a residue consisting largely of sodium tellurite, and in

addition containing selenite and silicate of sodium, is obtained. From this residue metallic tellurium is easily prepared. Melted tellurium resembles silver in colour, and antimony in general physical properties, is capable of being polished, and is very brittle. The authors endeavoured to employ tellurium commercially, and made alloys with lead and antimony. These are fusible with difficulty, in some cases only before the blow-pipe. The combination of lead and tellurium is attended with a large evolution of heat. W. C. B.

1149. *Thallium Alloys.* **N. Kurnakow** and **N. Puschin.** (Zeitschr. Elektrochem. 8. pp. 54–55, Jan. 23, 1902.)—The authors have investigated the solidifying-points of alloys of thallium with sodium, potassium, cadmium, tin, and mercury. They express their results by means of curves, taking the molecular percentages of thallium as abscissæ, and the freezing-points of the various mixtures as ordinates. In the case of sodium the solidifying-point at first falls on addition of thallium, and at the lowest-point reached a mixture of sodium and an indefinite alloy, Na_xTl (x varying between 2 and 6) separates. There is now a rise of freezing points, with breaks corresponding to the alloys Na_3Tl and NaTl, until the highest point is reached, a little above the melting-point of pure thallium. From this point the curve falls sharply and then rises to the freezing-point of thallium as an almost straight line. The curve for K-Tl alloys is very similar, except that there is no alloy with a lower solidifying-point than that of pure potassium. The mixture having the highest freezing-point, about 40° C. above that of pure thallium, corresponds with the composition KTl. By comparison with former results obtained by one of the authors, the conclusion is drawn that, in its alloys with Na, K, Sn, and Cd, Tl behaves as a heavy metal; whilst when alloyed with Hg, Pb, and Bi, it plays the part of an alkali metal. W. C. B.

1150. *Sodium-Potassium Alloys.* **N. Kurnakow** and **N. Puschin.** (Zeitschr. Elektrochem. 8. p. 55, Jan. 23, 1902.)—The authors give their results in the form of a curve of melting-points of varying mixtures of the two metals (see preceding Abstract). There are two distinctive points on the curve; one a transition-point corresponding with the composition Na : K = 1·5 : 1, and the other a eutectic-point when the composition is Na : K = 1 : 2. The authors conclude that when the proportion of sodium is large, an isomorphous mixture of the two metals separates, and at the eutectic-point an alloy of the probable composition Na_3K_2, but possibly Na_2K is found. W. C. B.

1151. *Aluminium.* **E. Wilson.** (Inst. Elect. Engin., Journ. 31. pp. 321–333; Discussion, pp. 334–339, Feb., 1902.)—The purest (99·6 per cent.) aluminium obtained commercially contains traces of iron and silicon. Commercial wire returns to its original length after the application of any stress up to 16,000 lbs. per sq. in. As soon as the proportion of copper (1·5 to 2 per cent.) is sufficient to give a breaking load of 40,000 and limit of elasticity of 33,000 lbs. per sq. in. the specific resistance rises to 3·3 from $2·76 \times 10^{-6}$ ohms for pure commercial aluminium at 15° C. The temperature coefficient falls to 0·0030 from 0·0040 : the linear coefficient of expansion is 0·000024, as against 0·0000234. Not much is gained in tensile strength by increasing the quantity of copper from 1·5 to 2·5 per cent. The alloy containing 1·29 per cent. Ni and 1·08 per cent. Cu gives a limit of elasticity 36,000 lbs. per sq. in. Its specific resistance is $3·41 \times 10^{-6}$ legal ohms at 15° C. Many of these alloys when erected between two horizontal points of support 120 ft. apart, the unstretched length of the wire being equal to the

distance between the points of support, and the temperature the standard temperature, are superior to copper for a given fall of temperature from a standard temperature. The small diameter of the G.P.O. experimental wires[1] may have something to do with the breaks which occurred, because two separately strung wires of equal diameter are not so good as one wire of the $\sqrt{2}$ diameter, although the total conductivities are the same in the two cases. Aluminium effects a saving in transport, since for the same conductivity only half the weight of aluminium need be used.

The following table, as well as two valuable tables of alloys, are given:—

Number of Wire.	Specific Resis. in 10^{-6} legal ohms at 15° C.	Conductivity in terms of Matthiessen's Standard at 15° C.	Temperature Coefficient 0° C. 100° C.	Linear Coefficient of Expansion per 1° C. between 18 and 103° C.	Specific Gravity.	Limit.		Break.		E.		Percentage Elongation on 350 mm. including break.	Percentage reduction of area at break.
						Load in lbs.	Tons per sq. in.	Load in lbs.	Tons per sq. in.	Lbs. per sq. in	Tons per sq. in.		
Averages of three specimens.	2·762	61·5	0·00405	0·0000234	2·715	250	8·65	—	12·60	8,512,000	3,800	1·86	73·6
Averages for two specimens.	2·762	61·5	0·00405	0·0000231	2·715	250	8·65	342	12·24	8,512,000	3,800	2·32	76·7
Averages for three specimens.	2·762	61·5	0·00393	0·0000230	2·715	95	3·4	182	6·44	1,683,240	751	22·5	88·2

M. O'G.

1152. *Ionisation, Ionic Velocities, and Atomic Sizes.* **W. Sutherland.** (Phil. Mag. 3. pp. 161–177, Feb., 1902.)—Thomson and Nernst have suggested that ionisation of a solute may be due to the high dielectric capacity of the solvent, others that it is caused by the association of the molecules of the solvent; the author proposes that high dielectric capacity, high power of ionisation, and tendency to molecular association may be all due to what he calls the latent valency of certain atoms. Thus, in the case of water, replacing the usual chemical bonds by pairs of electrons, he gives a symmetrical representation of the trihydrol molecule, in which oxygen appears as a tetrad different from the ordinary chemical tetrad in that of the four electrons attached to it three are negative and one positive. When this is dissociated, one of the negative electrons and the positive electron tend to form a neutron, but this takes time, during which they are at a certain average distance apart and have an average electric moment greater than that of the neutron. In discussing the behaviour of binary electrolytes, the need for taking account of viscosity is shown and a formula is developed for the specific molecular conductivity, which shows its dependence on the dielectric capacity of the solution. Polymerisation is suggested as the reason why Ostwald's law applies to the ionisation of weak acids and not to binary electrolytes, *e.g.*, for acetic acid the law probably is the expression of equilibrium between di-acetic acid and the products of its dissociation, while the polymerisation of sodium acetate is more

[1] Cp. Journal, I.E.E., 1901, vol. xxx. p. 359.

unstable in the presence of water. Graphs are given for several solutions, in which xi is plotted against $m^{\frac{1}{3}}$, i being the degree of ionisation of the solution, m its strength, and x a factor introducing the dielectric capacity, which differs little from unity for small values of m. These graphs are of parabolic form, but distorted for small values of m. In conclusion it is shown how the size of the molecule may be calculated from the observed ionic velocity, and suggested that this may be useful in the estimation of the molecular weights of large organic ions. W. E. T.

1153. *Melting-points of Dissociating Compounds.* **F. A. Lidbury.** (Zeitschr. Phys. Chem. 39. pp. 453–467, Jan. 17, 1902.)—By means of a slightly modified Beckmann freezing-point apparatus the author determined the temperature-concentration curves in the neighbourhood of the melting-point for the following systems:—(*a*) $CaCl_2.6H_2O$ (solid), $CaCl_2 + xH_2O$ (liquid); (*b*) $C_6H_5NH_2.C_6H_5OH$ (solid), $C_6H_5NH_2 + C_6H_5OH$ (liquid). The curves run through the melting-point parallel to the concentration axis, and show no "breaks." The crystallisation velocity was measured for the following: (*a*) $CaCl_2.6H_2O$ from solutions of $CaCl_2 + 5{\cdot}8$ to $6{\cdot}5$ H_2O, (*b*) $C_6H_5NH_2.C_6H_5OH$ from mixtures of aniline and phenol, (*c*) sulphuric acid from solutions of sulphur trioxide and water in sulphuric acid. The velocity changes steadily in value with change of concentration in the first two cases; sulphuric acid, on the other hand, shows a well-marked maximum. D. H. J.

1154. *Dissociation of Chloral Hydrate and Alcoholate in Solution.* **L. Bruner.** (Acad. Sci. Cracovie, Bull. 9. pp. 464–473, Dec., 1901.)—The author made ebullioscopic determinations of the molecular weights of these substances in a large number of solvents, with the result that in no case investigated, except in the case of the acetic acid solutions examined by Beckmann, is there any perceptible dissociation of either alcoholate or hydrate of chloral at the boiling-point of the solvent. On the contrary, an association was found for chloral and its hydrate in nitrobenzene, and for chloral alcoholate in methyl iodide, ethyl bromide, and carbon bisulphide. D. H. J.

1155. *E.M.F. of Daniell Cell.* **J. Chaudier.** (Comptes Rendus, 134. pp. 277–279, Feb. 3, 1902.)—If the copper sulphate is maintained saturated, and the zinc sulphate varied in concentration, the e.m.f. at first increases with the concentration, reaches a maximum when the solution contains $\frac{1}{2}$ per cent. of zinc sulphate, and then diminishes. The temperature coefficient is at first negative; it becomes zero for a solution of about the above concentration, and then positive, but again becomes zero at about $7\frac{1}{2}$ per cent., and finally negative once more. These results are discussed with reference to the Nernst and Helmholtz equations. W. R. C.

1156. *Gas-Cell Measurements.* **E. Bose.** (Zeitschr. Anorg. Chem. 30. 3. pp. 406–408, 1902.)—This is a remark on V. Czepinski's paper [see Abstract No. 920 (1902)]. The author gives a superior limit of $1{\cdot}154$ for the e.m.f. of the hydrogeno-xygen cell (at 25°), and suggests taking the mean value of this and $1{\cdot}12$ as the most probable figure. He then corrects a slight misunderstanding in Crepinski's quotation of his views. A. G.

1157. *Electrolytic Production of Crystalline and Spongy Tin.* **W. Pfanhauser, Jr.** (Zeitschr. Elektrochem. 8. pp. 41–43, Jan. 16, 1902.)—

The author endeavours to find some method for depositing firm coatings of tin on other metals. The chief advantages of tinning in the wet way over the present method of using a bath of the molten metal, are the lower cost and the less liability of injuring the more delicate parts of the objects by filling them with tin.' The bath given by von Roseleur, consisting essentially of stannous chloride and sodium pyrophosphate, was found by the author to deposit spongy tin after a few minutes' working. A large increase of concentration and altering the temperature and current produced no particular improvement. Stirring the solution caused the spongy tin to separate after a longer interval. The author finds that with increase of concentration of stannic and stannous chloride beyond normal solutions the production of spongy tin ceases when currents of small density are used; whilst with a current-density of over 1 ampere to 100 sq. cm. crystalline tin is formed. The production of thick coatings of the metal is possible by the use of very concentrated tin salt solutions, which contain no kations that could produce strongly dissociated solutions round the kathode. It is also necessary that there should constantly be a sufficient quantity of tin ions, and therefore of tin salt, in the neighbourhood of the kathode; for this reason the current-density must be kept small and the liquid stirred. The author also discusses the theoretical import of his experiments, and further describes two crystalline varieties of tin. W. C. B.

1158. *Electrochemistry of Double Salts.* **W. Kistiakowski.** (Zeitschr. Elektrochem. 8. pp. 71–72, Jan. 30, 1902.)—In this research the author's aim is to prove that the dissociation of salts in aqueous solutions may give rise to complex kations, as well as complex anions; *i.e.*, in addition to Hittorf's scheme, $M_2X_2 = M^{\cdot} + MX'_2$, the following may also occur, $M_2X_2 = M_2X^{\cdot} + X'$. Hellwig (Zeitschrift für anorg. Chemie. 25. 157) investigated the conditions of formation of the double salts AgI, $AgNO_3$ and 2AgI, $AgNO_3$, and found that the first exists in $AgNO_3$ solutions up to 0·712 normal, while the second is formed in concentrated solutions. The author examines the series Ag | $AgNO_3$(AgI), $AgNO_3$ concentrated | $AgNO_3$ | Ag, and finds that the difference of potential, varying from 1·6 to 3·6 millivolts with the concentration, agrees within the limits of experimental error with the value deduced from Nernst's formula $\pi = 0{\cdot}0608 \log \frac{C_1}{C_2}$. From the increased tendency of Ag to dissolve in $AgNO_3$ solutions on the addition of AgI, the author concludes that $Ag_3I^{\cdot\cdot}$ ions are present in the solution. Measurements are also given of the e.m.f. of the series M | KCN | MX | M, where M is a metal. The results are in accordance with theory, the observed e.m.f. being a measure of the tendency to form double salts. The author determines the transport numbers of various complex ions, and gives results of measurements, by an improved method, on the salts $Ag_3Cr(C_2O_4)_3$, $K_4Fe(CN)_6$, and $K_3Co(CN)_6$. The paper contains also a discussion of the chemical and electrochemical theories of formation of salts. W. C. B.

1159. *Electrolytic Oxidation of p-Toluic Acid.* **H. Labhardt** and **R. Zschoche.** (Zeitschr. Elektrochem. 8. pp. 93–96, Feb. 13, 1902.)—The authors give the results of their investigations on the electrolytic oxidation of *p*-toluic acid dissolved in alkali in order to escape the secondary reactions taking place when a methyl group is oxidised in presence of strong sulphuric acid. The products of the reaction are terephthalic acid, carbon dioxide, and monoxide. The kathode compartment of the electrolytic cell was shut off

gas-tight from the anode compartment, so that the oxygen given off could be collected and measured ; the difference between this quantity and the total oxygen evolved, determined by means of a control cell, represents the amount used up in oxidising the toluic acid. The best results are obtained with a spiral of copper wire as kathode and an anode of platinum. The influence exerted by the concentration of the acid, the amount of alkali present, the current density and the voltage on the oxidation were studied. It is not possible to convert *p*-toluic acid into terephthalic acid by the quantitative amount of oxygen, but conditions must be so chosen that a large percentage of the gas evolved takes no part in the reaction. T. H. P.

1160. *Measurement of Electrolytic Diffusion, Transport Numbers, and Mobility of the Ions.* **P. Straneo.** (Accad. Lincei, Atti, 11. pp. 171–177, Feb. 16, 1902.)—In the Atti R. Accad. Lincei, 1902, v. 11. i. pp. 58–65, a method was developed both mathematically and practically for measuring the electrolytic velocity constants in the case of complete dissociation of the electrolyte. In the present paper it is shown that an application of the elementary law of Fick for hydro-diffusion enables the theory, and therefore also the practice of measurement, to be immediately extended to the case of incompletely dissociated electrolytes. D. H. J.

1161. *Conductivity of Solutions of Mixed Electrolytes.* **H. Wolf.** (Zeitschr. Elektrochem. 8. pp. 117–119, Feb. 20, 1902.)—The influence of a third substance on the conductivity of an electrolytic solution is determined by (1) a change of ionic mobility ; (2) a change in the degree of dissociation ; (3) an isohydric influence, depending on double decomposition of the two solutes. Solutions of NaBr and of KCl of 0·0282N strength behave in a similar manner when mixed with acetic acid ; the decrease of conductivity amounts to 8·5 per cent. per mol. HAc per litre, and is due almost exclusively to increasing viscosity causing a decreasing ionic mobility. In a footnote, it is pointed out by Abegg that, on applying this correction to acetic acid itself, Ostwald's law of dilution holds good, not only to 0·2N, but up to N strength. In the case of N/2 solutions of KCl a *further* decrease of 0·5 per cent. occurs on adding 1 mol. HAc, owing to decreasing dissociation. A still larger decrease occurs when monochloroacetic acid is used in place of acetic acid, as here double decomposition occurs to an appreciable extent according to the equation $KCl + H\bar{A} = HCl + K\bar{A}$. By comparing such a series of mixtures the three causes of decreasing conductivity can be largely separated. Curves are given for the three cases referred to, for mixtures with alcohols and with tartaric acid, and also for solutions of zinc sulphate. T. M. L.

1162. *Voltameter for Small Currents.* **R. A. Lehfeldt.** (Phil. Mag. 3. pp. 158–159, Jan., 1902.)—The voltameter described by the author is suitable for the measurement of long-continued currents of very small magnitude, and is constructed as follows : A glass tube of from 0·5 to 1·5 mm. bore is provided with a pair of platinum electrodes sealed in near the ends, the latter being then drawn out to a small diameter. By means of a water-pump, the tube is then filled with mercury throughout except for one drop of mercurous nitrate solution in the middle. The tube is placed vertically, the upper portion of mercury being made the anode and the lower the kathode. The drop of solution creeps up the tube at a rate proportional to the current flowing, the movement being measured by any convenient scale, preferably one

etched on the glass, with or without a micrometer. The solution is prepared by weighing out about 26·3 m. grms. of mercurous nitrate per c.c. of water and adding enough nitric acid to dissolve the basic salt formed. The current density may have any value up to 10 or 15 milliamperes per sq. cm. but above this, polarisation is caused; a tube of 2 sq. mm. section will hence take 0·3 milliampere. Using a current of 1/12,000 ampere with the instrument constructed by the author, the observed rate of movement was 1 micrometer division (0·0785 mm.) in 1·073 hours, the calculated rate being one division in 1·067 hours. The details to be attended to in the construction of the voltameter are given. T. H. P.

1163. *Improved Electric Furnace for Laboratory Use.* **S. A. Tucker** and **H. R. Moody.** (Chem. News, 85. pp. 75–76, Feb. 14, 1902. From Journ. Amer. Chem. Soc. vol. 23, No. 7.)—The Moissan furnace is troublesome on account of its liability to crack in use, unless perfectly dry, and owing to the difficulty of using it for more than one operation. The authors substitute carbon bricks for the lime blocks, the electrodes being prevented from contact with the end walls through which they pass, by renewable collars of asbestos ¼ in. thick. The bricks are 12 in. × 4 in. × 2 in. luted with Dixon stove paste, and are bound with iron bands insulated from them by pads of asbestos, the carbon electrodes are surrounded at the free ends with copper sleeves lined with copper gauze, tightened with set-screws, which carry copper lugs holding the flexible cables. The ends of the electrodes projecting outside the furnace are protected from combustion either by water-jacketing or by heavily plating with copper. Using a single-arc furnace with a polar separation of 18 mm., and sufficient resistance in circuit, a current of 125 amperes × 70 volts = 8,750 watts was used. With a two-arc furnace, without resistance, the current was at first 175 amperes × 90 volts, but a few moments later was 125 amperes × 100 volts. A furnace with a working space 6 × 4 × 2 in., and with electrodes 1 in. in diameter, is suitable for use with currents up to 300 amperes × 70 volts. W. G. M.

1164. *Modified Moissan Electric Furnace.* **L. Liebmann.** (Zeitschr. Elektrochem. 8. pp. 125–128, Feb. 27, 1902.)—An account is given by the author of an electric furnace of the Moissan type, which can easily be put together by means of ordinary stoneware sections as used for enclosing electric cables in Germany. The furnace is of the resistance type, and semi-circular segments of stoneware serve as the bed and surrounding medium of the furnace. An easily arranged water resistance, as well as the other parts of the furnace, is shown by illustrations. Altogether the paper contains a number of useful hints for experimental work in this direction. O. J. S.

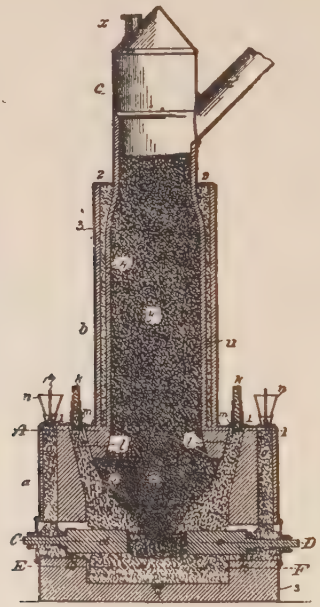
1165. *Experiments on the Manufacture of Aluminium.* **F. Haber** and **R. Geipert.** (Zeitschr. Elektrochem. 8. pp. 1–8, Jan. 2, and pp. 26–33, Jan. 9, 1902. From the Chemischtechnischen Institut at Karlsruhe.)—The authors produce aluminium by means of an experimental electric furnace. The furnace consists essentially of a block of artificial carbon in which a bath of the proper dimensions is cut. That employed by the authors is circular and is 70 mm. deep. The diameter at the bottom is 113 mm., and at the top 138 mm. Into this bath is lowered, by means of fine adjustments, a cylindrical carbon anode 66 mm. in diameter. Both carbons were of the best quality, and were made from materials as free as possible from ash. In the first experiment, 1,000 grms. of powdered cryolite and 200 grms. of alumina

were fused in the bath by means of an electric arc. 7 volts and 400 amperes were employed, the experiment lasting 290 minutes. During the run an additional 885 grms. of cryolite and 927 grms. of alumina were added. The average current strength was 310 amperes. 270 grms. of aluminium were obtained, the current efficiency being 54·3 per cent. The e.m.f. was 7 volts at the beginning and gradually rose to 10 volts at the finish, the mean value being 8·5 volts. Consequently the consumption of energy was 63 e.h.p.-hours per kg. of aluminium. A considerable quantity of aluminium was oxidised. The purity of the aluminium obtained and its mechanical properties were satisfactory. The results may be summarised as follows: The preparation of pure aluminium, from a mixture of cryolite, aluminium fluoride, and alumina may be easily accomplished in a furnace as above, using a current of 300–400 amperes at 7–10 volts, the kathode current density being 3 amperes per sq. cm. In order to obtain a good product, it is most important to start with the raw materials as pure as possible. The high percentages of aluminium fluoride facilitates the electrolysis, since the bath is thereby rendered more fluid, the temperature being bright red-heat. From the results obtained, the authors are of opinion that the modern successful electrochemical manufacture of aluminium is not due to secret alterations in the electrolytic process, but to the employment of purer raw materials and to the use of anodes containing as little ash as possible. O. J. S.

1166. *The "Bell" Gravity Process for the Electrolytic Production of Alkalies and Chlorine.* **J. B. C. Kershaw.** (Electrician, 48. pp. 618–619, Feb. 7, 1902.)—In this arrangement there is an inverted vessel or "bell" mounted in the electrolytic cell, with the inner surface of its top a short distance above the level of the electrolyte. Two pipes extend into this bell, one opening above the level of the electrolyte, to carry off the chlorine, and the other in the centre below this level, for supplying the electrolyte to the cell; there is an overflow pipe in one side of the outer cell for the outlet of the solution of caustic alkali formed. The anode is mounted inside the bell, some distance above the lower edge thereof, immediately below the supply pipe, whilst the kathodes are mounted outside just above the lower edge of the bell. By admitting the electrolyte above the anode, it is mixed with the liquid around the anode by the gas evolved at that place, thus keeping this liquid at a constant concentration. In the bell, the anode liquid saturated with anion is superposed above a certain part of the kathode liquid, which, beginning with a minimum strength of alkali, becomes more concentrated and specifically heavier from this point downwards, and at the lower edge of the bell has its maximum strength of alkali, which is identical with that contained in the liquid throughout the kathode compartment outside the bell. The fresh electrolyte is supplied at such a rate as to maintain these conditions. Ordinary thick lamp carbons are used as anodes, and are stated to last 1¾ to 2 years. The costs for caustic potash are as follows: Capital outlay on a plant producing 14,000 kg. of 90 per cent. caustic potash and 21,600 kg. bleaching powder per day with 4×600 h.p. generating units £150,000, working capital £10,000, making a total of £160,000. The working costs per day are: Electrical energy (1,400 kw. for 23 hours) £25 7s. 6d., coal and steam for concentrating caustic liquor £6 16s. 6d., potassium chloride (17,200 kg.) £166 12s., caustic lime (13,400 kg.) £10 11s. 9d., wages £23 12s. 6d., repairs £18 7s. 6d., packages £17 10d., general expenses (20 per cent. on above) £51 18s. 5d., depreciation (7 per cent. on £150,000) £28 13s. 8d., interest (5 per cent. on £160,000) £21 16s. 10d., making a total daily cost of

£371 6s. 8d. This process is being worked at Aüssig, in Austria, and at Bitterfeld and two other places in Germany. Costs are also given for caustic soda. C. K. F.

1167. *Electric-furnace Method of Producing Carbon Disulphide.* **E. R. Taylor.** (Elect. Rev. N.Y. 40. pp. 143–145, Feb. 1, 1902.)—An illustrated description of the process and apparatus for producing carbon disulphide, worked out and patented by E. R. Taylor. The process has already been tested on a commercial scale, and over 100 tons of carbon disulphide are stated to have been produced. A large plant is now being erected at Penn Yan, New York State, and a water-power at this spot is being developed for operation of the furnaces. Coke and sulphur are the raw materials of the



manufacture. The coke is charged into the upper portion of the furnace, which is shown in sectional elevation in the illustration. The sulphur is fed in at the annular openings in the lower part of the furnace, and is melted and vapourised by the electric current passing over the hearth of the furnace by the electrodes C and D. The sulphur vapour rising up through the heated coke combines with it, and the carbon disulphide vapour is drawn away to the condensers. As the furnace is of the resistance type, and the walls are well protected by sulphur and coke, there is not any appreciable wear and tear upon the lining of the hearth, and one furnace is expected to run several months before needing repairs. A further advantage of the electrothermal process is that it can be worked continuously, whereas the older process involved stoppages for charging and resetting retorts. The present output at Penn Yan with one furnace is 8,000 lbs. carbon disulphide per 24 hours, and apparently 330 kw. electric energy are being utilised in order to obtain this result. An output of 20,000 lbs. per 24 hours is expected when the works are completed. J. B. C. K

1168. *An Electrolytic Cyanide Vat.* **Irwin.** (Eng. & Mining Journ. 73. p. 112, Jan. 18, 1902.)—This invention consists of a series of tanks to retain the solutions, provided with an endless conveyor belt for carrying the ore from end to end of the series through the plant. The several tanks are similar in form, shallow, and each is provided with an inclined end, discharging into the next tank. The first tank contains caustic soda solution, the middle ones of the series cyanide, and the last tank is a filter designed to renew the exhausted cyanide solution. In the middle vats the conveyor functions as anode, and kathodes are inserted in these vats to receive the deposited metals. These kathodes are flat plates fixed parallel to the anode, one above and one below it. Wooden blocks fixed on metal cross-bars serve to stir up the ore lying on the conveyor as it passes through the cyanide solution. The novelty of the apparatus lies in its structural details, not in the principle. J. B. C. K.

1169. *The Substitution of Sodium Hydrogen Sulphate by Normal Sodium Sulphate in Brass-Plating Baths.* **A. Fischer.** (Elektrochem. Zeitschr. 8. pp. 247–248, Feb., 1902.)—The author has made experiments on a cyanide brass-plating bath advocated by von Pfanhauser (Elektroplattierung, 4. Aufl. S. 346.)—He finds that the mixture employed of sodium carbonate and sodium hydrogen sulphate may be advantageously replaced by an equivalent quantity of normal sodium sulphate. The two former salts do not react completely at the dilution used in the bath, and the unchanged sodium hydrogen sulphate causes a very poor deposit of brass. For copper-plating, on the other hand, a little of the acid sulphate may be added with advantage. The author recommends the following for brass-plating : 1 litre water, 4 grms. Na_2CO_3 (dried), 44 grms. Na_2SO_4 (dried), and 2 grms. NH_4Cl dissolved together, afterwards adding 20 grms. potassium copper cyanide, 20 grms. potassium zinc cyanide, and 1 grm. potassium cyanide. [See also Abstract No. 353 (1902).] W. C. B.

REFERENCES.

1170. *Physico-Chemical Measuring Apparatus.* **A. S. Cushman.** (Chem. News, 85. pp. 76–77, Feb. 14, 1902. From the Journal of the American Chemical Society, 23.)—A Kohlrausch-Ostwald conductivity-cell is described, in which the movable electrodes can be rigidly secured by means of screws. A modification of the Ostwald burette-calibrator is also described, in which the 2 c.c. pipette is provided with a scale instead of a single mark, so that the exact relative volume of each 2 c.c. of the burette can be rapidly determined without weighing. T. M. L.

1171. *Vapour Pressure of Ternary Mixtures.* **F. A. H. Schreinemakers.** (Zeitschr. Phys. Chem. 36. pp. 257–289, Feb. 22; 413–449, March 12; 710–740, April 19; 37. pp. 129–156, May 17; and 38. pp. 227–255, Aug. 23, 1901. Also Archives Néerlandaises, 5. pp. 214–226, 1900.)—A theoretical discussion of the various cases that may occur in the study of the vapour pressure of ternary mixtures. [See also Abstract No. 345 (1902).] T. M. L.

1172. *Constitution of Binary Alloys.* **J. A. Mathews.** (Frank. Inst., Journ. 153. pp. 1–22, Jan.; 119–140, Feb.; Discussion, pp. 221–230, March, 1902.)—This paper contains a valuable summary of recent researches, the subjects considered being the crystalline structure and effects of strain in pure metals; freezing-points of metals; alloys as solutions; molecular freedom in solids; solidification phenomena in binary alloys, cooling- and freezing-point curves; the nature of eutectics; solid solutions, alloys, and the phase-rule. G. W. de T.

STEAM PLANT, GAS AND OIL ENGINES.

1173. *Steam Turbine Trials.* **C. A. Parsons** and **G. G. Stoney.** (Inst. Mech. Engin., Proc. 4. pp. 797–812; Discussion, pp. 813–816, Sept., 1901. Paper read before the Glasgow Engineering Congress (Section III.), 1901.)—This paper contains a number of valuable tables giving the results of trials with turbo-dynamos. The author points out that the steam consumption closely follows a straight-line law, and that the fact that internal lubrication is not required obviates most of the difficulties encountered in the use of superheated steam for reciprocating engines, besides enabling the exhaust steam to be returned to the boilers direct without oil filters. The most interesting tests were those made at the works, of one of two 1,000-kw. turbo-alternators built for the city of Elberfeld, and constructed to give 1,250 kw. at 4,000 volts and 50 ∿, the alternators being four-pole, running at 1,500 r.p.m., and directly coupled to the turbines. The accompanying very instructive table is based on the results. The calculated figures in column 12 will enable comparison to be made with the steam consumption of reciprocating engines, working with saturated steam. Tests made to determine the advantages of superheating and the effect of varying the vacuum showed a gain of about 12° per cent. with 55° C. superheat, and that every inch of vacuum improves the consumption about 4 per cent.

Discussion.—**Schröter** stated that the trials made at Elberfeld six months after erection, the report of which would be published, gave even better results than the Newcastle trials, owing to slightly greater superheating, and that a comparison was made with a Sulzer engine driving a 1,000-kw. Brown-Boveri alternator in the same engine-house. The most noteworthy difference was that the steam consumption of the turbines, other things being equal, decreased constantly with increasing loads, whereas the piston-engine showed the highest consumption with maximum load. This was obviously due to the thermal pressure of the expanding steam being, in the case of the turbine, always equal to the condenser pressure, while the throttling increased with decreasing load; while, in the case of the piston-engine, the increased cut-off with increasing load increased the difference between the terminal steam pressure and that of the condensers. The turbo-alternators ran well in parallel, both with each other and with ordinary piston-engines. **W. Ripper** advocated high superheating (350° F. was employed in all the Schmidt type of engines), to which turbines were so specially adapted. He did not think sufficient emphasis had been given to the equality between the terminal steam pressure and that of the condenser. It was to utilise the work wasted in the case of piston-engines through the difference between these pressures, that the SO_2 engine tried at Charlottenburg had been devised. **G. G. Stoney** stated that tests made on turbines after long use showed no decrease in economy. With reference to superheat, no tests had been made at degrees higher than 100° F. which gave an economy of 12 per cent. With 350° F. this would probably reach 20 per cent. He stated that turbo-alternators were running successfully in parallel with every sort of engine at various stations. At Elberfeld the turbines were running sixteen times as fast as the Sulzer engines.

Load.	Average observed Steam Pressure. Absolute.	Corresponding Temperature of Saturated Steam.	Average observed Temperature of Superheated Steam at Inlet Valve.	Superheating. (Col. 4—Col. 3).	Observed Steam Consumption per kilowatt-hour.	Total heat contained in 1 kilogramme of steam at observed steam pressure.		Measured Consumption of Heat per kilowatt-hour (Col. 8 × Col. 6).	Corresponding Consumption of Saturated Steam per kilowatt-hour (Col. 9 ÷ Col. 7).	Corresponding Consumption of Steam at 11 kg. absolute and at 14·3° superheating. (1 kg. of steam = 669·2 cal.).	Corresponding Consumption of Saturated Steam at 11 atms. absolute (1 kg. of steam = 662·3 cal.).
						In Saturated condition.	In Superheated condition.				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Kilowatts.	Kg. per cm.²	C.°	C.°	C.°	Kg.	Calories.		Calories.	Kg.	Kg.	Kg.
1190·1	10·11	179·3	189·5	10·2	8·81	661·1	666·0	5,867	8·87	8·76	8·86
994·8	10·47	180·9	192·0	11·1	9·14	661·7	667·0	6,096	9·21	9·11	9·20
745·3	10·76	182·0	190·0	8·0	10·12	662·0	665·8	6,738	10·18	10·07	10·17
498·7	10·40	180·6	209·7	29·1	11·42	661·6	675·6	7,715	11·66	11·53	11·66
246·5	10·14	179·4	196·4	17·0	15·31	661·2	669·4	10,248	15·50	15·31	15·47
No load with excitation.	10·34	180·3	193·0	13·3	per hour. 1844	661·5	667·8	per hour. 1,231,423	per hour. 1861	per hour. 1840	per hour. 1859
No load without excitation.	10·49	181·0	194·5	13·5	1183	661·7	668·2	790,481	1194	1181	1194

1174. *Water-tube Boilers. Report on Trials of H.M.S. "Hyacinth" and "Minerva," and R.M.S. "Saxonia."* (Engineering, 73. pp. 278–282, Feb. 28., and pp. 326–331, March 7, 1902.)—This is a reprint of the Report issued by the Admiralty Committee on Water-tube Boilers, which embraces progressive trials of engines and boilers at 2,000, 5,000, 8,000 h.p. and full power ; and also full particulars of the trial runs to Gibraltar and back, which were previously noticed [see Abstract No. 2234 (1901)]. Voluminous details are given in tables and diagrams for which the original Blue Book must be consulted. The general effect of these trials is to show that the Belleville boilers of the *Hyacinth* are not so good as the Scotch boilers of the *Minerva* or *Saxonia*, except as regards thermal efficiency and the evaporation per lb. of coal from and at 212° F., in which the Belleville results were higher than the *Minerva's* but lower than the *Saxonia's*. The beneficial influence of retarders in the boilers of the *Minerva* was distinctly marked. F. J. R.

1175. *The Morrin "Climax" Steam Boiler.* (Engineering, 73. pp. 342–343, March 14, 1902.)—This boiler consists of a vertical cylindrical water-drum of steel, placed centrally in the boiler casing, with a large number of small water-tube loops extending radially round the entire circumference of the central drum, but placed at an angle so that one end of each loop pierces the drum at a higher point than its other end. These radial loops occupy all the space inside the casing from a short distance above the fire to nearly the top of the drum, which also projects downwards below the grate-bars. The fire-grate is annular in form and there are four firing doors, placed at equal intervals round the casing. The feed-water is heated in a special coil before it enters the boiler, and the steam is superheated by means of a series of diaphragms in the upper part of the drum which cause the steam to pass through the upper tiers of loops which are above the water-level. The steam then passes back into the upper part of the drum from which it is taken. The diaphragms also hinder priming. A report by Bryan Donkin on the performance of the boiler accompanies the article, which is illustrated.
F. J. R.

1176. *Feed-water Heaters in Condensing Plants.* **C. G. Robbins.** (Power, N.Y. 22. pp. 13–15, Feb., 1902.)—This paper contains a table of degrees of difference for various initial and final temperatures of water, and also a table of the number of square feet of heating surface required to raise 1,000 lbs. of water from various initial to various final temperatures, both on the basis of a steam supply of 126° and 141° F. in vacuum heaters and of 212° F. in atmospheric heaters. These tables and some examples are worked out from the data given by J. E. Lewis and H. L. Hepburn [see Abstracts Nos. 758 and 759 (1902)].
F. J. R.

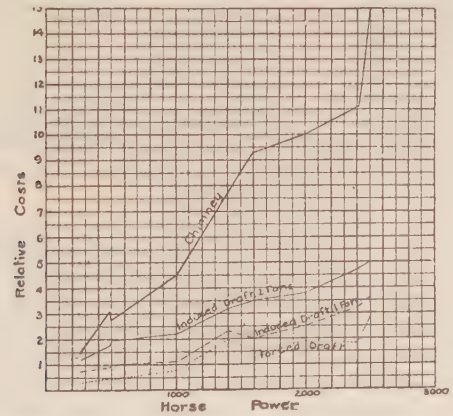
1177. *Mechanical Scale Remover for Boilers.* (Eng. and Mining Journ. 73. p. 250, Feb. 15, 1902.)—The Dean steam tube cleaner consists of a small cylinder for steam or compressed air, which has an oscillating piston inside to which a hammer is attached working outside, one end of the cylinder like the clapper of a bell. The vibrations of the hammer are very rapid and light. For water-tube boilers the hammer is formed as a chipper. Boilers must be dry when the machine is used. F. J. R.

1178. *The "Airedale" Feed-water Heater.* (Elect. Rev. 50. pp. 512–513, March 28, 1902.)—This is a heater of the vertical tube type, the peculiarity of

its design consisting in the use of a spiral retarder or deflector in the interior of the tubes through which the steam passes downwards whilst the water surrounding the tubes outside flows upwards in the casing. This aids the transfer of heat so much that the time required to heat the water from 70° and 200° F. has been reduced from 23½ minutes with the same tubes without deflectors to 5 minutes with deflectors. F. J. R.

1179. *Recent Progress in the Construction of Superheaters.* **M. Miet.** (Génie Civil, 40. pp. 232–235, Feb. 1, 1902.)—This article refers generally to the advantages of superheating, and notices the principal forms in use [see Abstract No. 2231 (1901)] adding a short description of the most recent French forms. These are a modern form of the Uhler, the Badére, Maiche, Piat, and Roser apparatus. The use of the thermo-electric pyrometer of Le Chatélier for regulating and controlling the temperature to which the tubes are exposed is discussed and the author concludes that the temperature of the heating gases rather than that of the steam should be observed. F. J. R.

1180. *Advantages of Mechanical Draught.* **H. F. Schmidt.** (Amer. Electn. 14. pp. 63–65, Feb., 1902.)—After enumerating the advantages, as regards the conditions of combustion and its completeness, of mechanically produced forced draught over induced draught, in which class chimney draught is included, the author investigates by means of figures the comparative efficiencies of the two systems. A chimney 180 ft. high, 10 ft. in diameter, an atmospheric temperature of 62° F., and escaping gases at 500° F., are taken as the elements of the investigation. The pressure produced by that chimney would be 6·25 lbs. per sq. ft. of area, and the corresponding height of a



column of air 82·1 ft., which, as a head, would cause a velocity of 72·71 ft. per second. From these data the useful and the total work done are computed, and on working out the same results for a fan having an efficiency of 0·5, with an engine consuming 50 lbs. of steam at 150 lbs. per sq. in. per h.p.-hour, and a boiler efficiency of 80 per cent., the fan is shown to be 71·3 times as efficient as the chimney. For a boiler plant consisting of 14 water-tube boilers, 2 economisers, and proper fittings, the costs belonging to chimney draught are $13,100, as against $6,300 for mechanical draught plant complete.

The above set of curves was prepared by W. B. Snow, from nine plants

with forced, induced, duplex induced, and chimney draught, and shows clearly the comparative costs of the various systems.

The author also works out the economy resulting from the use of a mixture of cheap coals, which could not be profitably used with chimney draught unless by a chimney of prohibitive dimensions and cost. F. J. R.

1181. *Automatic Feed Regulation of Steam Vehicle Boilers.* **J. E. Baldwin.** (Horseless Age, 9. p. 289, March 5, 1902.)—The author gives a *résumé* of the methods and principles at present employed in automatic feed-water regulators. C. R. D'E.

GAS AND OIL ENGINES.

1182. *Gas Engines.* **D. Clerk.** (Inst. Engin. and Shipbuilders, Trans. 45. pp. 1–43, Feb., 1902.)—The author reviews the history of the development of gas engines, and discusses the principles which have determined their increase in efficiency to the value of 30 per cent. now attainable. He describes various types of oil and petrol engines, and the large engines working with blast-furnace gases. Finally, he mentions his own experimental work and the various engines built on the Clerk cycle, with an impulse every revolution; a large number of engines are now being built to use this cycle. He believes that further developments will be on the lines of an impulse per revolution and of compounding. For marine work he thinks a constant-pressure flame engine would be required.

Discussion.—**Foulis** believed that explosion engines in large units would become too unwieldy, and looked to constant-pressure flame engines for further development. He described some experiments made by him on continuous ignition of gas mixtures, and pointed out that the difficulty was to avoid explosion and obtain continuous ignition. **Clerk**, in reply to several speakers, said that the Diesel engine was wrong in theory, and pointed out the serious danger of explosion in case of a failure to ignite. The advantage of compounding lay, not so much in saving exhaust pressure, as the maximum saving would be 10 per cent. in this, but rather in reducing the weight of the engine, which depended on the ratio of the average and maximum pressures. The paper contains numerous figures and plates. G. H. B.

1183. *Niel Gas Engine.* (Génie Civil, 40. pp. 362–363, March 29, 1902.)—A new gas engine constructed by the "Cie des Moteurs Niel" is described. It is intended for stationary use, and has a single horizontal cylinder working on the Otto cycle. Special attention has been given to the governing, which is effected by controlling the lift of the gas and air valves. These valves are mounted one above the other on the same stem, and are normally held against their seatings by an external spring. At the top of the valve stem is mounted the piston of an air dashpot; the ingress of air into the dashpot as its piston descends, with the valve stem, on the admission stroke of the engine, being regulated by a centrifugal governor. The valves are controlled from the admission cam on the cam-shaft by means of a telescopic rod coupled to a bell crank, one end of which is forked, and engages with a collar on the valve stem. A spring in the telescopic rod holds the roller at its lower end against the cam, and presses the bell crank fork against the valve stem collar in opposition to the tendency of the valve spring to hold the valves on their seats. The normal action of the admission cam is to compress the telescopic rod spring and cause it to overcome the valve spring so lifting the valves, but

if the governor comes into operation more or less vacuum is created in the dashpot as the piston on the valve stem descends, and the lift of the valves decreases as the combined pressure of the valve spring and pressure on the dashpot piston become more nearly equal to the downward pressure of the telescopic rod tending to open the valves. The following gas consumption figures are given :—

Running light	9·64	cubic metres per h.p.-hour.
Half charge, 25·26 h.p.	15·147	„ „
Full „ 46·02 „	20·194	„ „

The thermal efficiency works out at 18·8 per cent. on half and 25·5 per cent. on full charge, and the mechanical efficiency at 86 per cent. The normal speed is 216–219 r.p.m. C. R. D'E.

1184. *Bardon's Portable Combined Oil Engine and Dynamo.* (France Automobile, 7. pp. 186–187, March 22, 1902.)—In this article a detailed description is given of the conditions which have to be fulfilled by a combination of oil engine and dynamo, so as to be effective, economical, and at the same time portable. In the case described a 12-h.p. four-cylinder vertical engine is coupled direct to a dynamo, and both are fixed on to the same framework. Electrical ignition is employed. The oiling is done automatically. The dynamo used was a four-polar one, and capable of generating 50 amperes at 145 volts pressure and at 980 r.p.m. On trials made with that combination for 10 hours and 45 minutes the results obtained were: Current generated 42 amperes, voltage 149; 5, at a speed of 960 r.p.m., the power generated was 67, 2 kw.-hours, and the total oil consumed was 64 litres. This gives a consumption of 0·951 litres of oil per kw. generated, or 0·56 litres per h.p. Considering the price of oil to be 0·40 francs per litre, the expenditure per h.p. comes to 0·225 francs. The sizes made vary from 3 to 12 h.p., and the motors are accordingly made with 1, 2, or 4 cylinders. The dimensions of the combination used in the trial were : Length, 2 m.; width, 0·67 m.; and height, 1 m. The total weight was 1,000 kg. A side view of the combination is given. L. G.

1185. *Gasoline Motor Governing.* **C. E. Duryea.** (Automobile Rev. 6. pp. 27–28, Feb., 1902.)—This is usually effected by either completely or partially preventing the ejection of the exhaust, or by completely suppressing the admission. The author advocates governing by operating a throttle valve in the admission pipe in such a manner as to weaken the impulses without completely suppressing them. Cars fitted with motors controlled by a throttle valve can be driven like steam cars on one gear if a large engine is employed. C. R. D'E.

1186. *The Alcohol Motor.* **E. Neubery.** (Automotor Journal, 6. pp. 194–196, Feb., 1902.)—Gives the results of experiments made at the Technical High School of Berlin on a 4-h.p. alcohol engine by Körting Bros. coupled to a dynamo. The principal results are arranged in Table I., the experiments being divided into five groups :—

1. The series from 1 to 8 were for the purpose of determining the efficiency of the motor, alcohol of 92·5 per cent. being employed as fuel.

2. 9 to 12 show the effect produced by admixture of benzol and benzene. (They also serve as carburetting material.)

TABLE I.

No.	Percentage composition of the fuel.				Mean diagram pressure.	Temperature of the exhaust gases in degrees centigrade.	Indicated horse-power in i.h.p.	Effective horse-power in e.h.p.	Price per i.h.p. in Pfennigs.[1]	Price per e.h.p. in pfennigs.	Thermal efficiency, per cent.	Mechanical efficiency, per cent.	Total efficiency, per cent.	Converted into work, per cent.	Lost in cooling water, per cent.	Carried off in the exhaust gases, per cent.	Due to combustion to CO.	Remainder in per cent.
	Alcohol.	Water.	Benzol.	Benzene.														
1	92·50	7·50	—	—	2·97	349	2·90	1·462	13·10	25·92	17·73	50·5	8·98	17·73	35·75	18·81	1·108	26·602
2	92·50	7·50	—	—	3·22	370	3·12	1·620	12·27	23·53	18·95	51·9	9·87	18·95	32·70	20·72	0	27·63
3	92·50	7·50	—	—	3·88	345	3·56	2·646	11·08	14·90	21·00	74·3	15·63	21·00	33·49	18·10	0	27·41
4	92·50	7·50	—	—	3·86	356	3·79	2·960	11·08	14·13	21·00	78·1	16·42	21·00	36·47	21·81	1·012	29·808
5	92·50	7·50	—	—	5·68	323	4·28	3·566	11·21	13·39	20·85	83·2	17·35	20·85	38·84	16·76	1·388	22·162
6	92·50	7·50	—	—	4·85	338	4·40	3·788	10·26	11·89	22·70	86·2	19·55	22·70	34·10	15·51	1·069	26·621
7	92·50	7·50	—	—	5·74	308	4·72	4·278	10·15	11·15	22·90	90·9	20·80	22·90	33·67	10·45	0·912	32·068
8	92·50	7·50	—	—	5·82	324·99	5·05	4·076	10·05	12·45	23·10	80·6	18·65	23·10	44·15	15·01	1·117	16·623
9	84·075	6·825	9·1	—	5·22	341	4·82	4·047	10·08	12·00	21·85	84·4	18·34	21·85	40·14	13·36	0	24·65
10	77·1	6·25	16·65	—	5·38	337·5	4·68	4·037	9·18	10·62	22·90	86·1	19·72	22·90	39·90	12·07	0·0306	25·1094
11	85·075	6·825	—	9·1	5·38	321·5	4·43	3·606	9·12	11·12	26·17	81·3	21·24	26·17	43·33	16·08	1·090	13·330
12	77·1	6·25	—	16·65	5·66	339·5	4·99	4·006	11·15	13·72	21·79	80·2	17·72	21·79	43·41	12·68	0	22·12
13	67·50	32·50	—	—	2·72	346·5	2·38	1·265	18·85	34·50	12·35	53·2	6·75	12·35	26·02	11·20	1·145	49·285
14	78·66	21·34	—	—	3·49	356	3·50	2·274	12·10	18·42	19·39	65·0	12·60	19·39	33·07	16·83	0	30·71
15	87·188	12·812	—	—	4·81	338	4·44	3·564	10·03	12·80	22·60	80·4	18·17	22·60	36·17	18·77	0·0351	22·4249
16	77·802	22·198	—	—	5·32	324	4·62	3·414	10·03	13·95	22·49	73·9	16·67	22·49	32·79	17·80	0	26·92
17	79·344	20·656	—	—	5·78	346	5·23	4·263	10·01	12·48	22·98	81·3	18·64	22·98	38·19	13·97	1·095	23·765
18	60·57	39·43	—	—	6·54	321	5·38	3·146	9·25	15·76	25·19	58·5	14·74	25·19	26·67	9·35	0	32·79
19	92·50	7·50	—	—	5·34	308	4·92	3·840	9·51	12·40	24·56	78·1	18·74	24·56	35·10	10·5	0·292	29·548
20	92·50	7·50	—	—	3·255	321	3·72	1·718	11·12	24·17	20·93	46·2	9·67	20·93	31·23	15·15	0·331	32·359

[1] 8 pfennigs are equal to one penny.

3. The series 13 to 18 show the influence of different amounts of water mixed with the alcohol.

4. The series 19 and 20 shows the effect of the governor, which was not employed in experiments 1 to 18.

5. Experiments in which it was attempted to use pure benzol or pure benzene were not successful.

The mean values of the efficiencies work out as follows: Thermic efficiency, 21·215 per cent.; mechanical efficiency, 71·1 per cent.; total efficiency, 16·325 per cent. The cost of the alcohol and of other small motors per h.p.-hour is given in Table II.

TABLE II.

Kind of Engine.	Per H.P.-hour.					
	Depreciation.	Interest.	Attendance.	Oil.	Fuel.	Total.
Gas motor	3·34	1·335	1·04	0·9	8·53	15·145
Petroleum motor.....	3·34	1·335	1·04	0·9	8·25	14·865
Alcohol motor	3·34	1·335	1·04	0·9	15·35	21·965
Benzene motor.....	3·34	1·335	1·04	0·9	14·2	20·815
Acetylene motor	4·03	1·61	4·16	0·9	23	33·70
Electric motor	1·39	0·556	—	0·2	14·6	16·746

C. R. D'E

1187. *Letombe Motor.* (Écl. Électr. 30. pp. 173–174, Feb. 1, 1902.)—This is a vertical petrol motor having two cylinders of unequal bore, the small cylinder above the large, and on the same centre-line. A double piston, forming a single casting, enters the two cylinders, the smaller piston projecting up through the combustion chamber of the large cylinder, and leaving an annular ring of somewhat larger area than itself exposed to the pressure in the large cylinder. Each cylinder has its inlet and exhaust valves and ignition plug, so that they may be worked independently or together. The piston casting is coupled to the crank-shaft by a single connecting rod. Using both cylinders a working stroke is obtained at every revolution. A throttle valve is fitted in each induction pipe, which enables the relative proportions of pure and of carburetted air to be suitably regulated; beyond the point where the rotation of the throttle cuts off the carburetted air and admits pure air only, a further rotation causes a finger to hold open the inlet valve. The electric ignition for both cylinders is effected by a single induction coil and a high-tension rotary switch. C. R. D'E.

1188. *Fritscher Houdry Motor.* **L. Fournier.** (Locomotion Automobile, 9. pp. 102–104, Feb. 13, 1902.)—This is a four-cycle alcohol motor for stationary work, with a single horizontal cylinder 85 mm. bore × 160 mm. The carburettor is of the float-feed spraying type, and is mounted in close proximity to the exhaust box, both the air inlet pipe and the admission pipe to the engine being heated by the exhaust gases. A hit-and-miss governor is arranged to act on the admission valve. Between the mechanically operated admission valve and the cylinder is an automatic spring-controlled valve, the object of which is to prevent blowing back, the mechanical valve being so arranged that the internal pressure tends to force it open. The engine weighs 250 kg., and develops 1·27 b.h.p. at about 430 r.p.m. C. R. D'E.

1189. *Aster Governor.* (Horseless Age, 9. p. 266, Feb. 26, 1902.)—This is a compact form of centrifugal governor, actuating a throttle valve in the inlet pipe of a petrol motor. The throttle valve is of the piston type, and of considerable bore relative to the inlet pipe so that a comparatively short movement of the piston suffices for full opening or closing of the passage from carburettor to engine. C. R. D'E.

1190. *Fan Radiators.* (Locomotion Automobile, 9. pp. 119–121, Feb. 20, 1902.)—Several forms of radiators for cooling the jacket water on motor cars propelled by internal combustion engines are described. They are designed by J. Gronville and H. Arquembourg, and consist of spiral water-pipes having exterior radiating flanges, enclosed in a cylindrical case behind which is a fan driven from the engine. A continuous stream of air through the radiator is thus ensured at whatever speed the vehicle is travelling. C. R. D'E.

1191. *Kingston Carburettor.* (Automobile Rev. 6. p. 35, Feb., 1902.)—This carburettor is of the float-feed type, the float controlling a ball valve at the petrol inlet aperture. The carburettor jet opens into a box in which are interspaced discs of wire gauze. The air enters at the bottom of this chamber below the jet, and the top is connected to the induction pipe of the engine. C. R. D'E.

1192. *Favron Carburettor.* **P. Sarrey.** (Locomotion Automobile, 9. p. 121, Feb. 20, 1902.)—A small chamber, which is situated in a casting extending across the carburettor box, has three ports, one connected to the petrol supply, one to the jet, and one to a pump which is operated by the deflection of a diaphragm under the influence of the slight vacuum formed in the carburettor box on the suction stroke of the engine piston. The petrol inlet and the jet are normally closed by spring-controlled cone valves. The pump and central chamber having been filled on a suction stroke of the pump, the succeeding stroke forces the liquid out of the jet, the violent pulverisation assisting the carburation of the indrawn air. C. R. D'E.

1193. *Non-Freezing Liquids for Cylinder Jacket.* **E. E. Keller.** (Automobile Rev. 6. pp. 28–29, Feb., 1902.)—The properties of solutions of calcium chloride ($CaCl_2$) and of glycerine in water are discussed, and curves given showing the freezing- and boiling-points of solutions of varying strength. A solution of $CaCl_2$ of sp. gr. 1·2 freezes at about —15° F. and boils about 220° F. A solution of glycerine of sp. gr. 1·1 freezes about 0° F. and boils about 220° F. $CaCl_2$ is a cheap commercial article, and has practically no action on steel, iron, copper or brass, but acts upon galvanised iron and zinc to an appreciable extent. C. R. D'E.

AUTOMOBILISM.[1]

1194. *Steam Motor Cars for Railway Service.* (Eng. News, 47. pp. 102–105, Feb. 6, 1902.)—The advantages attaching to the employment of steam motor cars on branch lines where ordinarily a 500–800 h.p. locomotive is used for conveying, say, about twenty or so passengers is beyond all question, as under the latter circumstances traffic must be carried on at a dead loss. The steam motor has advantages not possessed by the storage battery, which has for

[1] Electric Automobiles are described in the Section dealing with Electric Traction.

such service been tried and found wanting, and, besides its many faults, is expensive both to establish and maintain. Its radius of action is also very small, cars so equipped being practically closely tethered to the power stations; which same objection applies also to the compressed-air motor and the different kinds of stored steam or superheated-water motors. The trolley and conduit systems have troubles of their own when concerned with the operation of long lines with light traffic, particularly in connection with the heavy cost of road and central station with capacity sufficient to take care of the maximum traffic. The internal combustion motor is at present unsuitable on the score of difficulties met with in starting. Several experimental steam cars have from time to time been tested in America without leading to any results beyond showing the enormous field which a successful steam car would open for cheap railway lines. The failure of the cars tested was due to the motor being designed too much on the lines of ordinary locomotive construction: to the cars having too much dead weight: to being designed for too high a speed and with too great a hauling capacity. Steam motor construction will be successfully developed by copying electric car construction and utilising speed-reducing gears placed between the engines and driving axle, while the employment of oil fuel may obviate the existing difficulties in connection with firing. The boiler design is a most cogent factor, and either a miniature Scotch boiler or a water-tube variety would probably meet the case.

The first car dealt with was constructed by the Schenectady Co. An old 60-ft. dining-car was taken, and one of the six-wheel trucks removed. This end was then altered for receiving the engine or "steam truck," the interior of the car being partitioned off for an engine-room. The vertical boiler (top 5 ft. 3 in., bottom 4 ft. 4 in.) was rigidly attached to the trunk or engine frame so that no flexible steam-pipes were required. It was fitted with a Regan water-grate. The storage of water gave rise to trouble, for this being gradually consumed during the trip, it was necessary to arrange the springs so that the car could ride easily with a variation of load of about 12,000 lbs. From running tests it was found, however, that no ordinary application of truck springs would give an easy riding body with the great load variation. The Erie R.R. had a similar car built, the rear end of the car being carried, in this case, by an ordinary four-wheel passenger car truck. Its use was discontinued because of the jar transmitted from the engine to the passenger end of the car and of the insufficiency of the boiler capacity. The Baldwin steam car—built for the Cincinnati, Hamilton, and Dayton Railway—had its boiler stationary in relation to the car body, resting upon the framing of the car, flexible connections being employed. The gear was arranged in the usual way, the special feature being the vertical boiler with a circular firebox tube and conical smokebox. Circular rows of 1¼ tubes were fitted between the plates, whilst a 10-in. tube passed through the centre, being connected at the top with a coal magazine surrounding the smoke-stack. Around the tube's base were twelve circulating tubes projecting down into the firebox and guiding the coal to the centre of the grate. This car was withdrawn from service after a few months, the automatic stoking not being a success, whilst the tubes became overheated and the boiler capacity was generally insufficient. Unpleasant vibrations and swaying of the car was caused by the tanks and condensers. Oil fuel was experimented with by way of increasing the steam capacity, but the want of room in the firebox of these vertical boilers precluded any chance of success. The Baldwin Car Company also built the steam motor used by the Pittsburg, Cincinnati, Chicago, and St. Louis Railway, with an engine of

the Vauclain four-cylinder compound type, valve gear of the Stephenson shifting link pattern, and a vertical boiler of the submerged flue type with a coal magazine round the smoke-stack. Boiler trouble again upset all calculations, the self-feeding arrangements not working properly. The Rowan steam car, extensively employed, has the engine and car portion separated, with an arrangement by which the front ends of the car sills would be supported on the engine frame. In this car the forward end is hinged and can be thrown open to clear the boiler. The steam "dummy" system is still in use on minor street and suburban U.S. railways, but speed is necessarily limited. C. E. A.

1195. *Loads on Horse Drawn and Motor Vehicles.* **E. R. Calthrop.** (Automotor Journal, 6. pp. 47–58, and pp. 61–63, Nov., 1901.)—Loads of 5, 7, and 10 tons are in ordinary use with horses. Five tons is the limit that can be carried on a motor waggon with a tare of 3 tons. But on a 3-ton motor waggon for which the existing English law prescribes a maximum width of 6 ft. 6 in., the available area of platform is 75 sq. ft. On the larger Liverpool horse-drawn lurries the platform surface (18 ft. 6 in. by 7 ft. 6 in.) amounts to 138 sq. ft. M. O'G.

1196. *Light Touring Cars.* **H. Ward Leonard.** (Horseless Age, 9. pp. 345–347, March 12, 1902. Lecture delivered before the Long Island Automobile Club, Feb. 26, 1902.)—The author goes carefully into points affecting the first cost, running and maintenance, &c., of a light motor carriage for pleasure purposes, comparing the merits of the three leading systems, viz., petrol, steam, and electric. He concludes by drawing up a table in which each type is judged with regard to safety, reliability, speed, depreciation, economy, hill-climbing, appearance, first cost, and noise and smell, and awards the petrol car the chief merit in the first five of these considerations, steam in the sixth and eighth, and electricity in the seventh and ninth. C. R. D'E.

1197. *White Steam Carriage.* (Horseless Age, 9. pp. 138–141, Jan. 29, 1902.)—This is a light vehicle for pleasure purposes, having seating accommodation for two persons. It has a tubular underframe, the front cross member of which holds the front wheel pivots, while the back cross tube encloses the live rear axle. The carriage body, together with engine, boiler, &c., are sprung from the underframe by four elliptic plate springs. The boiler is of the flash type, and consists of thirteen horizontal spirals, placed one above the other, of ½-in. metal tube, copper for the upper spirals, and steel for the lower ones next the furnace. The feed-water is supplied by a plunger pump worked direct off the engine, the feed being regulated by an automatic steam-pressure regulator. The feed-water enters at the centre of the top spiral, flows round this, then up and over this spiral and down into the second spiral, and so on, finally emerging as superheated steam from the external end of the bottom spiral, and thence passing to the engine under control of a throttle valve. The spirals constituting the boiler are interspersed with separating pieces and mounted in a cylindrical casing, at the bottom of which is the petrol vapour furnace. This consists of a flat cylindrical chamber closed top and bottom, and having numerous air-tubes passing through it vertically. Round the tops of the air-tubes are slits, through which the petrol vapour escapes from the interior of the chamber. The petrol in the supply tank is under air pressure. It passes through a vaporising coil before entering the

burner chamber, and the quantity of vapour passing is regulated by a thermostatic apparatus at the temperature of the steam in the boiler, and depending for its action on the difference in expansion of copper and iron. When the temperature exceeds a given value the petrol vapour is entirely cut off. An auxiliary burner for starting purposes is kept continuously alight, whether the main burner is on or off. Besides the automatic fuel regulator, a hand regulator worked from the driver's seat is fitted. The heating surface in the boiler is about 30 sq. ft. The average boiler pressure is about 200 lbs. per sq. in. The safety valve is set to 500 lbs. per sq. in. There is no gauge glass. The engine is of the simple two-cylinder vertical type, double-acting cylinders, 3 in. by 3 in., rated at 6 h.p. A link-reversing mechanism is fitted. Transmission to the live rear axle is by a single chain gear. Eight gallons of petrol and twenty gallons of water are carried. The total weight of the vehicle is 1,300 lbs. A photograph of the car and several diagrams are given. C. R. D'E.

1198. *Hoffman Steam Carriage.* (Automobile Rev. 6. pp. 36–37, Feb., 1902.)—This is a light two-seated steamer, propelled by a two-cylinder vertical engine, of 6½ h.p., cylinders 3 in. bore by 4 in. stroke, which is geared to the live rear axle by a chain drive. The boiler is of the water-tube type, fired by a gasolene furnace. C. R. D'E.

1199. *Eclipse Automobile Co.'s Carriage.* (Automobile Rev. 6. p. 36, Feb., 1902.)—In this carriage the boiler and engine are mounted below the carriage seats, as is usual in American light steam cars. The boiler is of the water-tube type, 20 in. diameter × 18 in. high, and contains 200 ft. of steel tubing. It is fired from below by a gasolene furnace. The engine is a three-cylinder vertical one, with piston valves, and the power is transmitted to the live rear axle by enclosed bevel gearing. C. R. D'E.

1200. *Barrière Steam Car.* **F. Mirés.** (Locomotion Automobile, 9. pp. 150–153, March 6, 1902.)—The general lines of this car are practically identical with the Locomobile steam car [see Abstract No. 547 (1902)]. The boiler furnace, which burns petrol vapour, is, however, considerably modified. The petrol is vaporised in a small, separate furnace, so arranged that steam may be rapidly raised although the car has been standing for hours with main fire extinguished. C. R. D'E.

1201. *Gardner Serpollet Steam Car.* **L. Fournier.** (Locomotion Automobile, 9. pp. 182–186, March 20, 1902.)—Describes the latest type of Serpollet steam car. The mechanism does not differ in any essential feature from that of earlier types [see Abstracts Nos. 903 and 1732 (1900)]. Detailed drawings are given. C. R. D'E.

1202. *Knoxmobile.* (Automobile Rev. 6. pp. 37–38, Feb., 1902.)—In this vehicle the front and rear axle, are connected by two long side-plate springs with swivel ends, the carriage body being attached toward the centre of length of the springs. A single cylinder horizontal engine of 8 h.p. cylinder 5 in. bore × 7 in. stroke transmits through an epicyclic gearing giving two speeds forward and one reverse, and a single chain drive, to the exterior of the differential gear on the live rear axle. The engine is air-cooled, and may be started from the driver's seat. C. R. D'E.

1203. *Fischer Motor Vehicle.* (Automobile Rev. 6. pp. 41–42, Feb., 1902.)—A three-cylinder vertical gasolene engine of 10 h.p. at 600 r.p.m. is mounted at the front end of a channel steel underframe. Direct coupled to the crank-shaft is the armature of a 5-kw. 110-volt dynamo, which supplies current to two 5-h.p. motors which drive the rear road wheels independently by spur reduction gears. The excess power developed by the engine when the car is travelling slowly or downhill is stored in a battery of 50 cells of 90 ampere-hour capacity. The engine always runs at its most economical speed. An 18-passenger omnibus has been successfully constructed on this system. C. R. D'E.

1204. *De Dion Bouton Novelties.* (Automotor Journal, 6. pp. 182–187, Feb., 1902.)—This article includes descriptions of (*a*) a new light electric motor vehicle; (*b*) a small stationary petrol motor and dynamo plant; (*c*) the new 8-h.p. de Dion Bouton petrol carriage. (*a*) The underframe and running gear of this vehicle are almost identical with the standard type of petrol carriage, by this firm, except that the change-speed gear is dispensed with. The motor is mounted below the tubular underframe and in front of the differential gear box; it is of the four-pole type with drum armature; its normal speed is 800 r.p.m. The controller is arranged to give four speeds by series and parallel grouping of the field windings and the battery. The reverse is controlled by a separate switch; 44 de Dion Bouton cells of 200 ampere-hours' capacity are carried within the body of the vehicle. (*b*) This set consists of a 3-h.p. single-cylinder vertical engine coupled direct to a Manchester type dynamo, designed to give 20 amperes at 110 volts at 1,300 r.p.m. Regularity of running is secured by the use of an electrically controlled throttle governor on the engine. (*c*) This vehicle has a tubular underframe sprung from the front axle by longitudinal, semi-elliptic, plate springs, and from the back axle by one transverse and two longitudinal springs; this latter spring being attached to the centre of the back cross tube of the frame. The motor is mounted at the front of the underframe; it has a single vertical cylinder, water-cooled, electric ignition, and governing by reducing the left of the exhaust valve; the flywheel is external to the crank chamber. The change-speed gear is coupled to an extension of the crank-shaft by a jointed shaft. Two speeds forward and one reverse are obtained by an expanding clutch method of keying any one of the free spur wheels to its shaft. Motion is finally transmitted from the differential gear to the rear road wheels by jointed shafts similarly to the method employed on other vehicles by this firm. C. R. D'E.

1205. *Eastmead Biggs Car.* (Automotor Journal, 6. pp. 188–190, Feb., 1902.)—In this vehicle the engine and transmission gear are attached to a tubular underframe, which is connected with the front and rear axles in such a manner that the axles may be tilted relative to one another in vertical planes without straining the frame. The carriage body is sprung from the underframe by semi-elliptic plate springs. The engine is of the vertical, single-cylinder type, and is mounted at the front of the underframe. The transmission is by a direct extension of the crank-shaft to the change-speed gear, which is of the spur-wheel type with sliding pinions and expanding clutches, and finally by a worm gear to the exterior of the differential gear on the live rear axle. C. R. D'E.

1206. *15-h.p. Mors Carriage.* (Horseless Age, 9. pp. 178–179, Feb. 5, 1902.)—The latest type Mors light car is illustrated and described. It has a four-

cylinder, vertical engine and a four-speed forward and one reverse change-gear. As in previous types [see Abstract No. 1735 (1900)], the engine is mounted towards the front of the underframe, the power being transmitted through a cone clutch to the change-gear square shaft, by a bevel gear to the differential cross-shaft and by chains to the rear road wheels. Front and side elevation, and a plan of the arrangement of mechanism are given. C. R. D'E.

1207. *Eldin and Lagier Carriage.* **P. Sarrey.** (Locomotion Automobile, 9. pp. 87–92, Feb. 6, 1902.)—This car is constructed broadly on Panhard lines. The engine is of the Daimler type, water-cooled, governing on the exhaust valves, and fitted with both tube and electric ignition. It is constructed in several sizes with two or four cylinders. The engine is mounted on a sub-frame attached to the rectangular wooden frame, and has its crank-shaft lying on the longitudinal centre line of the frames ; the power is transmitted through a cone friction clutch to the change-speed gear, which gives four speeds forward and one reverse by spur wheels engaged by side contact. A bevil gear transmits from the upper spur wheel counter-shaft to the differential cross-shaft, and the power is finally transmitted to the rear road wheels by chain gears. Several illustrations of the mechanism are given. C. R. D'E.

1208. *"Darracq" Light Motor Car.* (Motorwagen, 5. pp. 60–63, Feb. 28, 1902.)—This article describes the 9-h.p. type of "Darracq" motor car, which is of similar construction to those dealt with in Abstracts Nos. 566 (1900) and 555 (1901). The motor, which is of the single-cylinder water-cooled type, is supplied with a mixture of petrol and benzene, and its output is regulated by varying the proportions of the mixture. The motor and its accessories, and the gear transmission are clearly illustrated. J. G.

1209. *"Protos" Motor Car.* (Motorwagen, 5. pp. 39–41, Feb. 15, and pp. 57–59, Feb. 28, 1902.)—The two articles describe the "Protos" light car manufactured by A. Sternberg. The motor and speed reducing and reversing gear are mounted upon a separate frame, suspended from the fore part of the main running frame of the car. The gear is driven through a longitudinal bevel gear shaft coupled to the motor shaft by means of a spring friction clutch coupling, and a chain transmission is employed between the speed and reversing gear and the live rear axle of the car. The gear is adapted for two forward and two reverse speeds of driving, the required changes being effected by means of clutches. A chain adjustment is provided at the rear part of the frame, and for this purpose the springs which support the rear axle are connected to the frame by links, to permit of movement of the axle in adjusting the chain tension. The car frame and mechanism are fully illustrated, and a table is given showing the number of teeth in the change wheels of the speed gear. J. G.

1210. *Decauville Light Car.* (France Automobile, 7. pp. 155–157, March 8, 1902.)—The new 10-h.p. Decauville car is described. It has a rectangular tubular underframe carrying the motor and change-speed gear towards its front end, and sprung by long semi-elliptic plate springs from the axles. The motor is of the double-cylinder, vertical type, with electric ignition and governing on the exhaust valves. The cylinders are 110 mm. bore × 110 mm. stroke, and the normal speed is 1,000 r.p.m. The power is transmitted through a cone clutch to the change-speed gear, which gives four speeds forward and one reverse, the highest forward speed being a direct drive

without intermediary gearing. The lower half of the change-gear casing and of the crank chamber are formed in one casting, which also partially surrounds and protects the flywheel and clutch. The clutch is of the "Champion" type, with internal spring and working without end thrust when the power is on. The final transmission is effected by a jointed tail shaft and bevel drive to the exterior of the differential gearing on the live rear axle. The cooling water for the motor is circulated by a gear-driven centrifugal pump and cooled in a radiator mounted above the frame in front of the bonnet covering the motor. A complete plant, including dynamo, accumulators, and induction coils, is provided for the electric ignition. The motor is started on the cells, and at 600 revs. the dynamo is automatically brought into action, the current being divided between cells and induction coils. Above 1,000 revs., the cells are cut out so as to obviate overcharging. C. R. D'E.

1211. *Lepape Motor Vehicles.* **J. Caël.** (Locomotion Automobile, 9. pp. 166–168, March 13, 1902.)—The special feature in these vehicles is the motor, which has one working cylinder, water-cooled, and one cylinder acting only as a pump for sucking and compressing the explosive mixture. The cylinders are vertical and with pistons coupled to cranks at 120°. The pump cylinder sucks from the carburettor past an automatic inlet valve, and on the following up-stroke the charge is expelled past a second automatic valve into the working cylinder, the piston in which is then beginning to uncover exhaust ports in the cylinder wall towards the completion of a working stroke. The contents of the pump having been passed into the working cylinder, they are further compressed and exploded for the following down-stroke, there being one working stroke every revolution. C. R. D'E.

1212. *Vinet Light Car.* (France Automobile, 7. p. 166, March 15, 1902.)—In this car the underframe is of wood, reinforced with metal, the motor being mounted towards the front end. The transmission is by cone clutch to the change-speed gear, which gives three speeds forward and one reverse, with spur gears engaged by side contact. The power is transmitted from the change-gear countershaft to the differential cross-shaft by a bevel drive, and finally to the road wheels by chains. [See also Abstract No. 698 (1901).] C. R. D'E.

1213. *Clement Carriage.* (Horseless Age, 9. pp. 365–369, March 19, 1902. From La Locomotion.)—In this car an 8-h.p. double cylinder engine is mounted towards the front of the underframe, the transmission being effected through a cone clutch to the change-speed gear, and thence by a jointed tail shaft to a bevel drive on the live rear axle. The engine is of the vertical type, with cylinders 3·4 in. bore × 4·4 in. stroke, and its normal speed is 1,100 r.p.m. A special feature is the method of retaining the piston-pin in place. This is effected by an additional piston-ring on the central plane of the pin, which is thus restrained from endwise movement. The engine cylinders draw their charge from a simple form of float-feed spray carburettor. The change-speed gear gives three speeds forward and one reverse by sliding spur gears. The weight of the car empty is 1,100 lbs. C. R. D'E.

1214. *Oil Engine Road-Rollers.* (Engineer, 93. pp. 296–297, March 21, 1902.)—Particulars are given relating to two road-rollers propelled by oil engines manufactured by the Dudbridge Ironworks, Limited, of Stroud, Gloucestershire, the rollers themselves being of French make. The actual

rolling part of the machine does not differ essentially from the ordinary type, but an oil engine is substituted for the steam engine and boiler, the horizontal oil engine occupying much the same position as the boiler in a steam roller. The engine is rated at 16 h.p. and 180 r.p.m., and weighs about 70 cwt., the flywheel being 5 ft. 4 in. diameter by 7 in. wide. The consumption with any of the well-known brands of petroleum is stated to average 0·75 pint per b.h.p.-hour. The petroleum is vaporised in a carburettor heated by the ignition-tube burner. A compressed-air reservoir is provided for starting. Spur-gearing transmits the power to the rear road wheels, and a double-friction clutch is provided for forward and reverse motion of the machine. The rollers have been in successful operation for two years. C. R. D'E.

1215. *Acceleration of Automobiles.* **L. M. Aspinwall.** (Horseless Age, 9. pp. 320–321, March 12, 1902.)—The question of power required to accelerate motor vehicles is considered. In order to accelerate a vehicle at the rate of 1 mile per hour per second 4·55 lbs. effort at the rim of the driving wheels is required per 100 lbs. weight of vehicle. Curves are given which show the tractive effort which must be exerted per 100 lbs. weight to accelerate the same at from 0·25 to 2 miles per hour per second, and their application to the problem of finding the h.p. required to accelerate a vehicle of given weight to a given figure in miles per hour is explained. C. R. D'E.

1216. *Canda Motor Cycle.* **D. Bellet.** (Locomotion Automobile, 9. pp. 104–105, Feb. 13, 1902.)—This is a quadricycle of the well-known type, propelled by a single-cylinder, vertical petrol motor mounted behind the rear axle, and propelling this axle by means of a spur reduction gear. The article is illustrated by a diagram which shows clearly the relative positions and connections of engine, carburettor, and electric ignition apparatus. C. R. D'E.

1217. *Girardot Dirigible Balloon.* **L. Fournier.** (Locomotion Automobile, 9. pp. 134–136, Feb. 27, 1902.)—In this machine the load is lifted and supported by a cigar-shaped balloon, connected to which at either side in the longitudinal horizontal plane are æroplanes, the balloon being enclosed within and strengthened by the æroplane-supporting structure. At the centre of length of the balloon is a cylindrical chamber, below which is suspended a platform carrying the petrol motor which supplies the power for propelling the balloon. The two persons necessary for operating the machine are stationed in the central chamber, from which they have control over the several items of the mechanism. The power is conveyed from the motor to the propeller shaft by a belt drive. The propeller is situated at one end of the balloon, its shaft lying on the longitudinal centre line, and passing through a hollow stay which extends from end to end of the balloon. The machine is steered by operating two triangular sails at either side of the balloon.
C. R. D'E.

REFERENCES.

1218. *Structural Steel Details of Two-story Boiler-house.* (Eng. Record, 45. pp. 104–106, Feb. 1, 1902.)—This article contains sizes and details of the construction of columns and roof of the boiler-house erected by the United Railways and Electric Company of Baltimore. [See Abstract No. 416 (1902).] F. J. R.

1219. *Use of Balloons in War.* **E. H. S. Bruce.** (Soc. Arts, Journ. 50. pp. 277–283; Discussion, pp. 283–285, Feb. 21, 1902.)

GENERAL ELECTRICAL ENGINEERING.

1220. *Circuit-Breakers for High Pressure and Large Power.* **E. W. Rice, Jr.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 895–908, Dec., 1901.)—The author discusses the general considerations which should determine the design of large high-pressure electric power stations, with special reference to the switchboard arrangements, and the best form of circuit-breakers. At the recent experiments at Kalmazoo the circuit-breaker designed by the author for the Manhattan Railway Power Station [see Abstract No. 1372 (1900)] never failed to open 1,200- and 1,300-kw. circuits up to 40,000 volts, the highest pressure employed, without sign of fire or smoke, and quite noiselessly, and the author infers that they might be safely employed for much larger powers and pressures. Long break open-air switches are quite unsuitable, as even where sufficient room is available, they produce dangerously high resonance effects. At 40,000 volts, a circuit-breaker of this kind gave rise to an arc which held and flared to a length of over 30 ft., when it struck the line and short-circuited the system, producing at the same time high-voltage oscillations of two or three times the normal pressure. Another form of oil switch had evidently reached the limit of its capacity at 40,000 volts, flashing and, in some cases, smoking. Expulsion-tube air switches operated up to 25,000 volts, but failed at 40,000. G. W. DE T.

1221. *Automatic Cell Switch.* **P. Thieme.** (Elektrotechn. Zeitschr. 23. pp. 174–176, Feb. 27, 1902.)—The article describes an attachment applicable to an ordinary cell switch, consisting of a motor with worm gear actuated by a voltmeter relay, which closes the motor circuit for forward or backward motion, according as the pressure is too high or too low. G. H. B.

1222. *Kinsman Block System for Steam Railways.* (Elect. World and Engineer, 39. pp. 306–308, Feb. 15, 1902.)—This is a system by which the throttle valve of the locomotive is closed when a section of line ahead is blocked. At the entrance to each section are two "guard" or "contact" rails quite separate from the traffic rails, and slightly above the level of the latter, to which, however, they are secured by tie-plates, so that the relative difference in level is always the same. These "guard" rails are run over by two "contact" wheels mounted on the locomotion axle, but insulated therefrom. These wheels touch only the "guard" rails and avoid all cross-overs and frogs. Collectors press on the wheels to guide the current to an electromagnet on the engine. When such current passes, which is arranged to occur when a distant semaphore arm is to "danger," the magnet pulls up its armature and lets go a lever which works a valve. This movement operates to stop the steam supply and to apply the pneumatic brakes. The engineer has a lever within reach interlocked with this mechanism so that he can restore everything to its normal condition by throwing it forward, and this can be done so quickly that very little of the train's momentum need be lost. There is, however, no chance of his mistaking the character of the signal thus given. The ends of the "guard" rails are slightly bent downward to prevent injurious shock from the contact wheels. There is nothing movable on the

roadbed to be clogged, broken, or displaced, and, owing to the formation of the contact wheels, the "guard" rail cannot become ineffective by reason of snow, ice, or other like obstruction. E. O. W.

1223. *Electrical Method of Determining the Velocity of Underground Water.* **C. S. Slichter.** (Eng. News, 47. p. 151, Feb. 20, 1902.)—A double row of 1¼-in. drive test wells are sunk across the channel of the river whose underflow is to be tested. The up-stream wells are charged with a strong electrolyte (ammonium chloride giving the best results). This dissolves, and passes down-stream with the moving water. The passage of the electrolyte towards the lower wells is shown by the gradual movement of the needle of a sensitive ammeter, and the final arrival at the well is shown by a sudden and strong deflection of the needle. If several of a row of wells are being used simultaneously, the main stream of the underground current will show itself by the rapidly rising electrical currents in certain of the wells. The electric circuit to the wells can be made in several ways. A brass rod, insulated from the well tube, and lowered into the down-stream well by means of a rubber-covered wire, may serve as one electrode, the casing of the same well constituting the other, the electrodes being connected by the ammeter and a battery. In this case, the indication of the movement of the ground water will not be noted until the electrolyte has reached the lower well, where its presence will be shown by a sharp rise in the current curve. Instead of this, the two wells themselves may be used as the electrodes, in which case the gradual passage of the electrolyte can be observed from the beginning, but the final indication of its arrival will be less pronounced. The best method is a combination of the two. The wire from the casing of the lower well is run to one pole of the battery through the ammeter; the other pole of the battery is connected to the internal electrode of the lower well through a resistance, and also to the casing of the upper well. The drive wells may be made of perforated sections from 4 ft. to 6 ft. long, so that a well will offer free passage to the water throughout its entire depth. E. C. R.

1224. *Electric Cranes at Middlesborough Docks.* (Electrician, 48. pp. 606–609, Feb. 7, and pp. 688–689, Feb. 21, 1902.)—Three 10-ton and seventeen 3-ton jib cranes have been erected, together with twenty-four 1-ton capstans. In the 3-ton cranes the height of jib top from the quay level is 60 ft., the radius of jib is 44 ft. 9 in., the speed of lifting 3 tons is 150 ft. per minute, speed of lifting 1½ tons is 250 ft. per minute, the revolving speed at the hook is 400 ft., and the travelling speed 30 ft. per minute. Details of construction are described in the first article. The controller is a combination of two controllers, which are actuated by one lever. One controller actuates the lifting motion and the other the slewing motion. The lever which controls them is so arranged that when moved in a vertical plane it actuates the lifting and in a horizontal plane the slewing controller. The capstans are capable of hauling loads of 100 tons along a level road. Upon the motor shaft there is fixed an automatic mechanical brake, which locks itself if the capstan tends to run backwards through being overloaded. Tests were made on the 3-ton cranes, and it was found that a complete cycle of operations required 0·17 unit of energy. The operations included lifting 3 tons through 30 ft., slewing through 120°, lowering 3 tons 30 ft., hoisting unloaded hook, slewing back through 120°, and lowering hook to ground. This cycle of operations can quite easily be performed forty-five times in an hour, and with a practised driver a still higher rate of speed is possible. W. H. S.

REFERENCES.

1225. *"Mars" Meter.* **J. A. Montpellier.** (Électricien, 23. pp. 49–51, Jan. 25, 1902.)—The "Mars" is a motor meter of the Thomson type, and presents no novel features except in details of construction. G. H. B.

1226. *Westinghouse Meter.* (Elect. Rev. 50. p. 267, Feb. 14, 1902.)—The meter is an alternate-current induction motor of the usual type. G. H. B.

1227. *Objects of Interest to Electrical Engineers in the Glasgow Exhibition of* 1901. **W. B. Sayers.** (Inst. Elect. Engin., Journ. 31. pp. 9–23, Dec., 1901.)—A description is given of the generating station and of numerous exhibits, including dynamos, motors, and transformers; gas, oil, and coal dust-engines; electrically driven machinery; telephone apparatus, &c. G. W. DE T.

1228. *Electrically-driven Tools.* (Engineer, 93. pp. 119–120, Jan. 31, 1902.)—A description, with photographs and some detailed drawings, of several portable, electrically driven machine tools (slotting, planing, and drilling machines) constructed by Messrs. Kendal and Gent, of Manchester. H. R. C.

1229. *Electric Locking of the Charles River Drawbridge.* (Railroad Gazette, 34. p. 89, Feb. 7, 1902.)—A very brief description with several diagrams, showing the way in which the movement and locking of the bridge are electrically controlled by the signalman. The work was carried out by the Union Switch and Signal Company of America. [See also Abstract No. 733 (1900).] W. H. S.

1230. *Wellman Furnace-charger.* (Génie Civil, 40. pp. 257–260, Feb. 15, 1902.)—The article describes an apparatus which is used for charging Siemens-Martin furnaces, and is operated electrically. W. H. S.

1231. *"Ricks" Accumulator.* **A. Ricks.** (Centralblatt Accumulatoren, 3. pp. 29–31, Feb. 1, 1902.)—The article contains some general particulars regarding this cell and curves of discharge with electrodes of various thicknesses. E. J. W.

GENERATORS, MOTORS, AND TRANSFORMERS.

1232. *Standardising Electrical Machinery.* **G. Kapp.** (Inst. Mech. Engin., Proc. 4, pp. 825–840; Discussion, pp. 841–845, Sept., 1901. Paper read before the Glasgow Engineering Congress (Section III.) 1901.)—In this paper the author deals with the standards for rating and testing electrical machinery provisionally adopted by the German Association of Electrical Engineers in June, 1901, a complete translation of the regulations being given as an appendix to the paper. They deal with generators, motors, rotary converters, motor generators, and static transformers. For rating purposes a division is made into three classes, according to the time during which they are to be used, viz., (*a*) intermittent use; (*b*) short-time use; (*c*) continuous use. Class (*a*) includes motors for cranes, hoists, traction, &c.; class (*b*) those in which the period of work is shorter than necessary to reach the final temperature, and the period of rest is long enough to permit the temperature to fall approximately to that of the air. The rated power is to be that which can be given off (*a*) for one hour without exceeding the temperature limits; (*b*) for a number of hours stated in a plate attached to the machine; (*c*) continuously. In the latter case the temperature rise is measured after a ten hours' run in the case of moving machinery, and whenever it has reached a stationary value in the case of transformers. The temperature limits, in ordinary cases, and if the air-temperature does not exceed 35°; of insulated conductors, commutators, and slip-rings, are, for cotton-covered wire 50°, for paper-covered wire 60°, and for wires insulated with mica, asbestos, &c., 80°, an additional 20° being allowed in each case for tramway motors. With regard to overload, it is pointed out that this should only occur for a short time, and under such temperature conditions that the permissible temperature rise is not exceeded, and, with this limitation, it is provided that generators, motors, and converters must be capable of an overload of 25 per cent. for half an hour, on the condition that, in the case of alternators, the power factor should not be lower than that marked on the plate; while motors, converters, and transformers must be capable of an overload of 40 per cent. during three minutes, on the condition that, for motors, the normal terminal pressure is to be maintained. The measurement of insulation resistance is not prescribed, but a breakdown test at high voltage, and this has been designedly kept within reasonable limits, since a breakdown test at very high voltage may, even if the machine stands it, cause permanent injury.

The most difficult task of the committee was the framing of rules for testing efficiency, and this has been met by giving eight methods, and leaving to the maker the right of selecting the one to be used, which is to be specified in his tender.

In the course of the discussion, **P. E. Huber** observed that his experience indicated that a test of eight to ten hours was not always conclusive for machines having to stand continuous work under full load (*e.g.*, for electrochemical purposes), perhaps for months. Such machinessome times showed their defects only after two or three days' continuous working. The **Author,** in the course of his reply, referred to the important point raised by Huber as

one that might be reconsidered. A ten hours' test might or might not be enough for big machines, depending on their construction. G. W. DE T.

1233. *Calculation of Field Rheostats.* **R. Krause.** (Elektrotechn. Zeitschr. 23. pp. 66–68, Jan. 23, 1902.)—The author developes a simple method of calculating the number of steps and the value of the resistance corresponding to each step in a field rheostat, so as to enable the p.d. to be kept within certain limits as the load is steadily increased. The experimental data assumed by the author are the magnetisation curve of the machine and the value of the exciting current corresponding to full load at the normal p.d. A. H.

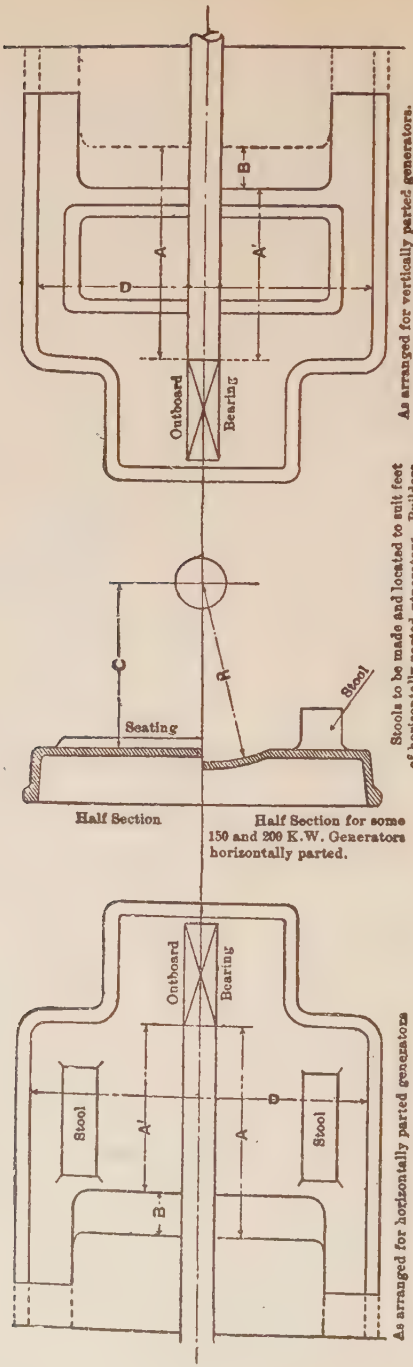
1234. *Standardising Direct-connected Continuous-current Units.* (Amer. Soc. Mech. Engin., Trans. 23. No. 916, pp. 99–108; Discussion, pp. 108–110, Dec., 1901. Also Elect. Rev., Jan. 24 and 31, 1902.)—The report deals only with units up to 200-kw. capacity, and the endeavour has been to reduce the number of standard units as far as possible. The diameters of shafts have been decided by the permissible deflection, and it is to be noted that the recommendations apply only to engines of the usual proportions, with the dynamo attached at the side of, and not between, the cranks. Owing to the marked difference in generator shaft-length adopted by different makers for the same power, generators are divided into "long" and "short," having a maximum difference of 6 in. in length of shaft, as shown in the accompanying table. To reduce the cost of patterns for the different lengths of sub-base, a standard pattern is proposed, with a standard adjustable end for each unit. The dimensions chosen for the height of the axis of the shaft above the top of the sub-base are sufficient to allow for vertically-split machines, and also, except in the case of the two largest units, to clear the periphery of horizontally-split machines. This allows of the use of one main pattern, to which patterns for the stool, or the rectangular seatings, required for the two classes of machines respectively, can be attached, as shown in the accompanying illustration, before the pattern is sent to the foundry. In the case of the 150 and 200 kw. units, a recess is to be provided in the top of the sub-base to allow the lower part of some horizontally split frames to be accommodated, and thus avoid unduly raising the shaft. In the case of those which do not need it, including all vertically-split machines, the top of the sub-base will be flat and continuous. *Armature fit.*—The allowance for a pressed fit is fixed at $\frac{1}{1000}$ in. for 4-in. to 6-in. shafts, and $\frac{2}{1000}$ in. for $6\frac{1}{2}$ in. to 11 in., and is to be by increased shaft diameter. It is recommended that the dynamo maker should furnish the engine builder with a gauge the exact diameter of the bore. *Overload Capacity.*—It is recommended that the standard overload rating should not exceed 25 per cent. of the rated capacity, and some engine builders suggest calling attention to the importance of special attention when the unit is so operated. Various other minor suggestions are made. Straight keys are recommended, to be used as feathers, their lengths being left optional. *Discussion.*—**W. A. Drysdale** observed that in installing over eighty plants within the last few years his practice had exactly agreed with the table, except that he used larger shafts, to allow for defects in forging. With regard to overloads his practice had been to require an excess above the normal rating of 25 per cent., and an overload of 50 per cent. for a few minutes. He then described an "Armature Jack" successfully used in all his work for placing the armature on, and removing it from, the shaft.

Table of Sizes, Speeds, and Standardised Dimensions of Direct-Connected Generating Sets.

Capacity of Unit, Kilowatts.	Revolutions per Minute.	Armature Bore.		Diameter of Engine Shaft at Armature Fit.		Space Occupied on Shaft between the Limit Lines.		*B*, Length of Extension Pieces, Inches.	*C*, Height of Axis of Shaft above Top of Base, Inches.	*R*, Inches.	*D*, Width of Top of Sub-Base, Inches.	Key (a Feather)				Holding-Down Bolts.	
		Centre Crank Engines, Inches.	Side Crank Engines, Inches.	Centre Crank Engines, Inches.	Side Crank Engines, Inches.	Long Class *A*, Inches.	Short Class *A'*, Inches.					Width, Inches.	Thickness, Inches.	Depth in Shaft at Edge, Inches.	Projection above Shaft at Edge, Inches.	Diameter, Inches.	Number.
25	310	4	$4\frac{1}{2}$	$4 + \frac{1}{1000}$	$4\frac{1}{2} + \frac{1}{1000}$	30	25	5	$23\frac{1}{2}$	Flat.	48	1	$\frac{3}{4}$	$\frac{3}{8}$	$\frac{3}{8}$	1	4
35	300	4	$5\frac{1}{2}$	$4 + \frac{1}{1000}$	$5\frac{1}{2} + \frac{1}{1000}$	33	28	5	25	Flat.	54	1	$\frac{3}{4}$	$\frac{3}{8}$	$\frac{3}{8}$	1	4
50	290	$4\frac{1}{2}$	$6\frac{1}{2}$	$4\frac{1}{2} + \frac{1}{1000}$	$6\frac{1}{2} + \frac{2}{1000}$	37	31	6	28	Flat.	60	$1\frac{1}{4}$	$\frac{3}{4}$	$\frac{3}{8}$	$\frac{3}{8}$	1	4
75	275	$5\frac{1}{2}$	$7\frac{1}{2}$	$5\frac{1}{2} + \frac{1}{1000}$	$7\frac{1}{2} + \frac{2}{1000}$	43	37	6	31	Flat.	66	$1\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{1}{2}$	$1\frac{1}{4}$	4
100	260	6	$8\frac{1}{2}$	$6 + \frac{1}{1000}$	$8\frac{1}{2} + \frac{2}{1000}$	48	42	6	34	Flat.	72	$1\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{1}{2}$	$1\frac{1}{4}$	4
150	225	7	10	$7 + \frac{2}{1000}$	$10 + \frac{2}{1000}$	51	45	6	$37\frac{3}{4}$	$41\frac{1}{4}$	84	$1\frac{3}{4}$	$1\frac{1}{4}$	$\frac{5}{8}$	$\frac{5}{8}$	$1\frac{1}{4}$	4
200	200	8	11	$8 + \frac{2}{1000}$	$11 + \frac{2}{1000}$	54	48	6	$42\frac{3}{4}$	$47\frac{1}{2}$	96	2	$1\frac{1}{4}$	$\frac{5}{8}$	$\frac{5}{8}$	$1\frac{1}{2}$	4

Note 1.—Five per cent. variation of speed permissible above and below speeds in table.

Note 2.—Distance from centre of shaft to top of base of outboard bearing may be less than *C* (to suit engine builder), though not less than possible outside radius of armature.


B
A
A'
D
Outboard
Bearing
As arranged for vertically parted generators.
Rectangular seatings to be made and located to suit bases of vertically parted generators.
C
R
Seating
Stool
Stools to be made and located to suit feet of horizontally parted generators. Builders of latter note that radius of outside of field piece must be ¼" to ½" less than "R."
Half Section
Half Section for some 150 and 200 K.W. Generators horizontally parted.
Outboard
Bearing
Stool
A'
B
D
A
Stool
As arranged for horizontally parted generators

G. W. DE T.

1235. *Self-Exciting Alternator.* **M. Latour.** (Ind. Élect. 11. pp. 77–78, Feb. 25, 1902.)—The author has devised a generator closely resembling the one described by Heyland [see Abstract No. 2475 (1901)]. Imagine a stator consisting of a laminated hollow core provided with a low-resistance star-connected three-phase winding. This forms the armature of the generator. Inside the stator is placed the rotor, which carries the inducing or field-winding. The core of the rotor may be either *solid* or laminated, and its winding would consist of a continuous-current armature winding, provided with a commutator and brushes placed in suitable positions. If three-phase currents be fed into the rotor through the brushes, they will give rise to a rotating magnetic field, the angular velocity of which depends on the frequency of the current and the number of poles. The angular velocity of this field *in space* will obviously be quite independent of the angular velocity of the rotor. By driving the latter at the speed of synchronism in a direction corresponding to that of the field, relative displacement of field and rotor is prevented, the rotor winding loses its counter-e.m.f., and behaves like a non-inductive resistance. If the field is connected direct across the generator terminals, its resistance must be sufficiently high to stand the full p.d. without excessive heating; the winding would, therefore, be a high-resistance winding, precisely analogous to the field-winding of a continuous-current shunt-wound machine. Since the field-winding is practically short-circuited by the armature winding, it forms a very effective damping coil, and prevents hunting. The author next considers the action of such a shunt-wound alternator when used as a motor. It may be made to run synchronously at all loads by a proper adjustment of the brushes for each load. A. H.

1236. *Alternators in Parallel.* **della Riccia.** (Écl. Électr. 30. pp. 413–419, March 22, 1902.)—The different causes which effect the angular velocity of the rotor of an alternator are enumerated. The angular velocity (ω) of the rotor is given in the form $\omega = \Omega\,(1 + \frac{1}{\delta}\sin k\Omega t)$, where Ω is the mean angular velocity, k the time of a complete revolution of the rotor divided by the periodic time of the variations of the turning forces acting on it; and $1/\delta$ is the "irregularity," so that $1/\delta = (\omega_{max} - \omega_{min})/2\Omega$. Hence if θ be the geometric lag at any instant between any radius of the rotor and the position it would have had if its velocity were Ω, then $\theta = \int(\omega - \Omega)\,dt = -1/\delta k \,.\, \cos k\Omega t$. If the alternator have $2p$ poles, the lag of the actual vector of the e.m.f. behind the mean vector (α) will be given by $t - p/\delta k \,.\, \cos k\Omega t$. The problem of two similar machines working in parallel is then discussed, and algebraical solutions are obtained for the e.m.f.'s of the two alternators, their cross-currents, &c. It is proved that in order to prevent the irregularity of one of the alternators being greater than when it is running alone, the flywheel inertia must be increased by a certain amount, a formula for which is given. A. R.

1237. *Tests of Heyland's Compensated Induction Motor.* **A. Heyland.** (Elektrotechn. Zeitschr. 23. pp. 28–30, Jan. 9, 1902. Also Electrician, Jan. 24, 1902.)—The author gives an account of some preliminary experiments carried out by the Vereinigte Elektricitäts-A.-G., with a single-phase induction motor constructed as recently described by the author [see Abstract No. 2475 (1901)]. The experimental motor used in these tests was in reality a three-phase, 12-h.p., 6-pole, 300-volt, 50-cycle motor. Two of its phases were left connected in series, and were supplied with a single-phase current, while the third phase was disconnected, and a portion of it used for supplying the

exciting current to the rotor through two diametrically opposite brushes. The rotor was provided with a continuous-current wave winding connected to a commutator whose segments were bridged by non-inductive, low-resistance strips. In using the machine as a single-phase motor, the brushes were first adjusted to correspond to the highest power-factor, and then the number of turns (of the third phase) used for supplying the exciting current was varied until a power-factor of unity was obtained, the final adjustment being obtained by slightly displacing the brushes. When used as an ordinary single-phase motor, this machine had a power-factor of 0·75 at full load, and a no-load current of 15 amperes. By using the compensating device, the power-factor could be made equal to unity, and the no-load current reduced to 3 amperes. The machine was next run as a self-exciting generator. At first it refused to retain its excitation, but on increasing the speed beyond a certain limit it could be switched off from the source of supply, and would then go on running, supplying its own exciting current. When loaded, it had a drop of voltage from no-load to ¼ load amounting to 2 per cent. The author suggests that a small hand-machine might be used for giving such a compensated generator the first impulse required to start its excitation.

A. H.

1238. *Testing Motor Losses.* **W. E. Sumpner.** (Inst. Elect. Engin., Journ. 31. pp. 632–641; Discussion, pp. 641–645, March, 1902.)—The magnitudes of the frictional and other losses in motors and dynamos are deduced by Swinburne's method from the way a running machine slows down. In the first way described the only apparatus required is an ordinary watch, a good speed indicator, and some means of applying to the machine a small measured retarding torque. The approximate equation $T = T_0 t'/(t - t')$ is proved, where T is the retarding torque due to losses in the machine, T_0 is a known mechanical torque, t is the time the machine takes to slow down from R_1 r.p.m. to R_2 r.p.m. when T is the torque and t' is the time the machine takes to slow down from R_1 to R_2 when $T + T_0$ is the torque. Now by varying the excitation we can measure by the same means a new value of T, and so separate the torque due to hysteresis and eddy currents from the torque due to friction. The torque may also be applied electrically by Hay's method [see Abstract No. 2493 (1900)]. If W be the watts wasted due to machine losses, and w be the watts generated in the machine during the test, then, as before, $W = wt'/(t - t')$. It is pointed out that for alternators running in parallel the synchronising apparatus can be employed to measure the speed by means of the method of beats. The speed can also be determined in many cases by using a low-pressure voltmeter to measure the difference between the volts of the field-magnet coils and the induced e.m.f. in the armature. The results of tests by this method of a Parker dynamo belted to a Tangye gas engine are given. In the discussion, **Henry Lea** said that he thought that the losses when the dynamo is driving the engine with constant effort would be very different to the losses when the engine is driving the dynamo at full load. In his reply, the **Author** stated that he had aimed at raising a discussion on the most suitable means of testing machines with simple instruments and without the necessity of troublesome preliminary arrangements. The methods described were best adapted to test large machines.

A. R.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

1239. *Capacity in Transmission Lines.* **G. Sartori.** (Elettricista, Rome, 11. pp. 41–44, Feb., 1902.)—The author shows that the capacity of a wire at a given distance from the earth is twice that which would be due to another wire at twice the distance. He works out numerically the case of an overhead transmission line of three wires, showing that, neglecting the effect of the earth, and considering only the effects of the wires on one another may lead to an error of over 50 per cent. A. E. L.

1240. *Plant Erection at the Manhattan Railway Power Station.* (Street Rly. Journ. 19. pp. 74–84, Feb., 1902.)—The article describes, with numerous illustrations, the various steps in the assembling of one of the units, consisting of a Reynolds' engine direct-coupled to a revolving field Westinghouse generator, these being of interest on account of the unusual size of the units [see Abstract No. 977 (1901)]. Before placing the shaft in its bearings, the generator hub and cranks were forced on by a portable hydraulic press with a capacity of 500 tons pressure. The weight of the flywheel generator field (370,000 lbs.) causes a deflection in the shaft, which had to be allowed for by making the axes of the low-pressure cylinders approach each other by 7/32 in. at the top. The requisite inclination of the cast-iron columns on which the cylinders rest was obtained by means of a 30-in. spirit-level, furnished with a graduated glass upon which was marked the necessary deflection, calculated from the weight of the field and the rigidity of the shaft, and which amounted to 0·0095 in. in 30 in., the length of the level. The hub of the field, which is of cast steel, was placed in position on the shaft before attaching the peripheral castings or web plates which take the place of spokes. In building up the field, the main rim, to which the laminated field poles were to be attached, were placed in position and held by temporary spokes before the side webs were put on. There are four of these sections, and they were built up around the spokes, with the wheel in a stationary position, and keyed together. After the rim had been bolted and keyed together, it was trued upon the inside by a gauge-rod placed between the hub and the rim. The temporary spokes were provided with turnbuckles, consisting of long nuts with fine right- and left-hand threads, by means of which the field was accurately centred. The web plates are made in sections, and the first few put on were staggered on each side of the rim around the field. These held the rim in position while the temporary spokes were removed. At the centre of the web, strengthening plates were riveted to the sections before they were erected. The remaining connections in the construction of the wheel are made with heavy bolts, which pass through holes reamed out after the plates were in position. At the sides of the hub, outside of the web plates, are placed two large strengthening rings. The hub contains ridges which engage in corresponding recesses in the inside parts of the web, to diminish the strain on the bolts when running, and give increased rigidity.

G. W. DE T.

1241. *Wrexham Central Station run with Refuse.* (Electrical Times, 21. p. 51, Jan. 9, 1902.)—W. Sillery, the Borough engineer, reports that during December, 1901, the whole of the steam required for the station was obtained from the Meldrum four-cell refuse destructor, with the exception of Sundays and the Christmas holidays, when there was no collection of refuse. A table showing the maximum load, units generated, and hours of running for each day in the month are given. The units of electric energy generated per ton of refuse burnt are stated to average 37·8. G. W. DE T.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1242. *City of London Electric Lighting Company's Continuous-current Plant.* (Electrician, 48. pp. 723–730, Feb. 28, 1902.)—This paper gives a description of the extensions made in 1899 and 1900. These include three 1,000-kw. and two 2,000-kw. machines. The 1,000-kw. machines are Allis-Westinghouse combinations, the engines being of the vertical cross-compound condensing type, with 28-in. and 60-in. cylinders and 48-in. stroke running at 90 r.p.m. The 2,000-kw. machines are Musgrave-Westinghouse combinations, with 38½-in. and 76-in. cylinders and 54-in. stroke, running at 75 r.p.m. An important feature of this generator is the employment of the Westinghouse system of compensated armature winding, wherein certain points of the armature windings, which should be at equal potentials, are connected together by additional conductors, so that if there is any difference of potential between these points, on account of want of magnetic balance, there will be a flow of current through the corresponding conductors in one direction or the other. These currents interact on the field magnets either demagnetising or magnetising them to produce the necessary state of balance. Full details are given of the construction of these dynamos. The surface-condensers are of the Edwards type, constructed by Messrs. de Ritter and also by Messrs. Musgrave. An illustrated description of a special form of automatic exhaust relief valve is given. This value is partly counterbalanced by an external weight connected thereto by a flexible wire rope which passes into the exhaust pipe through a pipe having a gland and stuffing box at its outer end. The valve, when open, rests against a central shield which deflects backward pulsations of steam and thus prevents chattering. The generators supply three-wire 2 × 202 volt networks Balancing is done at substations on the network by Parker balancing transformers, and also at the station by an ordinary Parker open hand-regulated balancer running at 620 r.p.m. The fuses are designed by O. L. Peard, and consist of a plaster-of-Paris base having a spring slide of the same material pressed outwards against the fuse-strip; at this point, the fuse-strip is thinned and protrudes through the plaster-of-Paris cover. The middle wire of all networks is earthed at the generating station, this earth connection being attached to the lead coverings of the various feeding and distributing cables which are placed in separate wrought-iron pipes. The paper is illustrated by a number of drawings and photographs. C. K. F.

1243. *South London Electricity Works.* (Elect. Rev. 50. pp. 223–227, Feb. 7, 1902.)—The works are owned by the South London Electric Supply Corporation, and serve the parish of Lambeth. The Company agreed to destroy the refuse of the parish for 11½d. per ton. The district is 6 miles long, and varies in width from ¼ mile to 2 miles, and is, in parts, of a scattered nature. The high-pressure single-phase alternating-current

system is used, and the generating plant consists of five coupled sets, four of which have Ferranti engines and "copper" type alternators. The latter work at 3,000 volts, 50 cycles per second, and the outputs are : one, 1,000-kw. at 160 r.p.m., one 1,200-kw., and two 300-kw., each at 350 r.p.m. The exciters are driven by ropes from the engines. The fifth set consists of a Yates & Thom engine, coupled to a British Thomson-Houston alternator, giving 500 kw. at 250 r.p.m., and is provided with an automatic expansion governor acting on the high-pressure cylinder only. Eight Babcock & Wilcox double-drum boilers, each capable of evaporating 10,000 lbs. of water per hour, form the steam-raising plant, and deliver superheated steam at 200 lbs. per sq. in. Mechanical stokers were at first used, but discontinued owing to smoke nuisance. The refuse destructor (temporarily disused owing to litigation) consists of sixteen cells arranged one on each side of a boiler, and are charged by means of special trucks, the arrangements being very similar to the Shoreditch plant. The steam-piping is on the ring main system, with a cross connection in the centre, and the flanges are of the spigot and socket type. The feed-piping is in duplicate throughout. The feed-pumps are driven partly by steam and partly by electric motors, the latter being double-wound and operated on the series-parallel method. Surface condensing plant is installed in a subway under the engine-room, capable of dealing with 28,000 lbs. of steam per hour, and the circulating water is cooled in a creosoted wood tower. The switchboard provides for running the plant in two groups, or all in parallel. No difficulty is experienced in paralleling, notwithstanding the different wave forms and other characteristics of the alternators. The 3,000-volt switches are of the single oil-break type. An illuminated indicator board, visible from all the stop valves, and operated from a keyboard by the switchboard attendant, is used to convey instructions to the drivers. Six feeders supply independent high-pressure networks, which feed independent low-pressure networks through transformers in street boxes. The high-pressure feeders are laid in earthenware ducts, and the low-pressure mains on the solid systems. All the cables are paper-insulated, lead-covered. A time switch is used to switch the street arc lamps in and out at the proper times. F. B.

1244. *Electric Lighting and Power at the Philadelphia Mint.* **C. W. Pike.** (Elect. World and Engineer, 39. pp. 201–205, Feb. 1, 1902.)—This is a large isolated plant installation of a very complete nature. The steam-raising plant consists of eight Babcock & Wilcox 150-h.p. boilers, designed for a pressure of 150 lbs. per sq. in., arranged in two sets of four boilers each. For artistic reasons, the buildings being of considerable architectural beauty, the use of a high chimney-stack was undesirable, and forced draught is therefore employed, produced by a 96-in. Sturtevant fan. This is capable of being driven by either of the two engines fixed at the ends of the shaft. The steam-piping, of which a plan is given, is made up of three systems, in duplicate—high, medium, and low pressure. The medium pressure, obtained by means of reducing valves, is used on the auxiliaries, and the low pressure is used for heating. The power plant consists of four direct-connected slow-speed units. The engines are by the E. P. Allis Co., and the dynamos by the Crocker-Wheeler Co. The sizes and speeds are : one 100-h.p. set at 150 r.p.m., for the night load, one 200-h.p. set at 135 r.p.m., and two of 300-h.p. at 100 r.p.m. The steam consumptions per i.h.p. per hour are 21·5 lbs. for the largest, and 23 lbs. for the smallest engine. Long air-gaps are provided in the generators, so that inaccuracy in centring, or wear in the bearings,

has but a small effect on the magnetic balance. The voltage is 250. Individual motor-driving is used for almost every purpose, the installation including up to the present 121 motors, ranging from $\frac{1}{6}$th-h.p. to 50-h.p., and aggregating over 750-h.p. There are four 3-h.p. topping machines (for cutting off the rough ends of the ingots), six 50-h.p. ingot rolling machines, six 25-h.p. finishing rolling machines, nine $\frac{1}{2}$-h.p. "strip" annealing furnace travellers, nine $\frac{1}{4}$-h.p. rotary furnace travellers, twelve $7\frac{1}{2}$-h.p. coining presses, and twelve of 3-h.p., twelve 3-h.p. cutting presses, ten $\frac{1}{6}$-h.p. automatic weighing machines, and ten 3-h.p. up-setting machines (for raising the edge). The presses, of course, vary in size, according to the denomination of the coin. The average speed of coining is 85 pieces per minute, and the total pressure required for the large coins is 170 tons. Photographs show the method of driving the various machines. Eight elevators are employed, having motors varying in size from 30 to 50 h.p. The switchboard and wiring system are described. The lighting installation comprises 4,000 incandescent and 16 arc lamps. The telephone and fire-alarm systems are also described; the former is on the exchange system and serves 51 instruments. Thirty alarm boxes are distributed throughout the building, and the turning of the handle of any one automatically records its number five times on the ink-writing register, and simultaneously two gongs strike the number. Diagrams of storage battery connection, and plans of engine-room and switchboards are given. F. B.

1245. *Bristol Electricity Works.* (Electrician, 48. pp. 643–648, Feb. 14, 1902.)—The old station contains plant of 3,150 kw., of which all but 450 kw. is alternating, and is fully loaded; owing to lack of space, extensions cannot be made, so a new station has been laid down at Avonbank. The lighting load is to be gradually transferred to the new works, and the old station will be used for power supply only. The foundations of the new building consist of concrete piers, owing to the marshy subsoil. Coal is conveyed from barges on the Feeder River to bunkers at the top of the boiler-house by a gravity railway and Hunt bucket conveyor. There are four Babcock-Wilcox boilers at present, with superheaters and Meldrum stokers. Induced draught is used, the steel chimney being only 70 ft. high; the fan is driven by a Chandler steam engine, automatically controlled by the boiler pressure. There will be three Siemens copper-type alternators, of 745 kw. each at normal load, driven by Willans 3-crank engines; two Siemens dynamos, of 165 kw. each, with Willans 2-crank engines, have been installed to provide power to drive the motors, &c., on the works. Allen surface condensers and Doulton water softeners have been provided. The switchboards are of the Ferranti type. The alternators are paralleled through an impedance coil, as at the old station. The latter is fed from the new works through three 0·3 sq. in. trunk mains, of Siemens concentric paper-insulated and lead-covered type. There are 55 substations. A. H. A.

1246. *Partick Municipal Electricity and Destructor Works.* (Electrician, 48. pp. 892–896, March 28, 1902.)—The *boiler-room* contains four boilers each with 2,010 sq. ft. heating surface and 39 ft. grate area. Three of the boilers have two "destructor cells," each capable of consuming 10 tons each of refuse per diem. The complete destructor and boiler plant with fans, economiser, &c., is supplied by Manlove, Alliott & Co. The feed-water is heated by the exhaust steam from the main engines, fan engines, and pumping engines. The water is from the Glasgow Corporation mains. The *engine-*

room contains two 150-kw. and two 75-kw. Bellis-Peebles steam dynamos. The engines by Messrs. Bellis Morecomb run at 500 r.p.m. The larger units are triple expansion and the smaller units compound. The cylinders have piston slide valves. Each engine drives direct a four-pole shunt-wound dynamo by Messrs. D. Bruce Peebles & Co., generating at a pressure of 480 to 520 volts. The balancer consists of two 15-kw. machines coupled together and the booster of two 15-kw. dynamos on the same shaft as a 30-kw. motor. *Feeders* of triple concentric and lead-covered type from the British Insulated Wire Co. are drawn into Doulton conduits and are of sections varying between 0·3 and 0·06 sq. in. They terminate in feeder pillars in place of ordinary manholes. Each pillar is made for one feeder and six distributors. Total length of feeders is 6 miles. Distributors of the same make as the feeders are laid for about 8 miles, besides 4 miles of arc cables. The station is equipped with a double battery of 284 Tudor L.B. 11 type accumulators capable of discharging at 75 amperes for eight hours, or 180 amperes for three hours. The equivalent of 7,000 8-c.p. lamps has been applied for.

J. L. F. V.

1247. *Berkshire Street Railway Company, Mass.* (Street Rly. Rev. 11. pp. 65–69, Feb., 1902.)—This line, which is 50 miles long, receives power from a station at Pittsfield. Three-phase current is generated at 13,300 volts; at this pressure it is sent along a transmission line, and converted at substations to 380 volts for use in connection with rotary converters, which supply direct current at 600 volts. The insulators for the high-tension line are of glass, and have petticoats 7½ in. in diameter. W. H. S.

1248. *The Aurora Elgin and Chicago Railway.* (Street Rly. Journ. 19. pp. 107–110, Feb., 1902.)—This railway is being constructed to take 40-ton cars running at a scheduled speed of 40 miles per hour, including stops, with the stations 3 miles apart, and a maximum speed of 65 miles an hour, on the General Electric multiple unit system. Each car will have four 125-h.p. General Electric motors, the motor equipment being designed to give a maximum speed of 70 miles an hour on the level. The construction is being carried out with "a solidity which savours strongly of English steam railroad construction." The track rails weigh 80 lbs. per yard, and are in 60-ft. lengths. A third rail of T form, weighing 100 lbs. per yard, is to be used, except on a small portion which does not run over a private right-of-way. The conductivity will be sufficient to enable copper continuous-current feeders to be dispensed with. The power is to be transmitted at 26,000 volts over three-phase lines supplying converter stations which will feed the third rail directly, and will not be normally sectioned, but all tied together. These 26,000-volt feed-lines will be of aluminium, and so arranged as to give a duplicate feed to the greater part of the road. A telephone-despatching system is to be used, and the substation attendants will receive messages from the despatchers, and deliver them to the train crews. G. W. DE T.

1249. *Hartford and Springfield Electric Tramway.* (Street Rly. Journ. 19. pp. 90–94, Feb., 1902.)—The power-house, brick-built with steel roof trusses, is nearly in the centre of the line, on the banks of the Connecticut River, and has a brick chimney 130 ft. high with a core 6 ft. in diameter extending nearly to the top. The boiler-house is 51 ft. 8 in. by 49 ft. 5 in., and the engine-room 105 ft. by 91 ft., the floor being 12 ft. above the basement, which contains the steam-piping, air-pumps, condensers, &c. Exhaust steam from

each engine is carried directly into an American feed-water heater, and then into a Knowles twin vertical air-pump and condenser through the usual valves. Drips and condensed water from the steam mains, &c., are collected in a Holly receiver, and returned directly to the boilers, and another pump and receiver return the condensations from the car-house and office-heating systems, which are supplied from the power-house. There are two batteries of water-tube boilers by the Aultman Taylor Company, having a rated capacity of 750 h.p., with space for the addition of 500 h.p. In the boiler-room are two duplex double-plunger Deane boiler-feed pumps, each capable of running the entire plant. An auxiliary feed-water heater, placed near the pumps, receives the exhaust steam from the feed-pumps, air-pumps, and receiver. The steam main is carried on adjustable roller brackets, and long-turn steel bends connect it to the boilers and engines by short runs and heavy by-passed O.S.Y. valves. The fire exhaust is carried to the roof and topped with an exhaust head. The water passes usually through all the heaters, but the numerous long-turn bends and valves are so arranged that any or all of the heaters can be cut out if necessary. The lagging consists of 85 per cent. magnesia. The station at present contains two cross-compound engines by the Wetherell Engine Company, each direct-connected to 300-kw., 500-volt, continuous-current General Electric generators controlled by a Standard General Electric switchboard. Space is left for a third unit. The track is laid throughout with 70-lb. steel rail, A.S.C.E. standard section in 30-ft. lengths, with Weber joints, and 8-in. stranded concealed bonds. The feeder wire is 500,000 circular mils throughout, and No. 00 trolley with Craighead flexible brackets is employed. G. W. DE T.

1250. *St. Paul and Minneapolis Interurban Railway.* (Street Rly. Journ. 19. pp. 159–170, March, 1902.)—This paper deals mainly with the causes which have made such a great financial success of this line. Great stress is laid on the high character of the track construction. Of the 251 miles of track, 76 miles have cast-welded joints. Twenty-five miles on paved streets have 80-lb. T-rails, 7 in. high, laid without ties, with a concrete beam 15 in. wide by 8½ in. deep under each rail. The track is held to gauge by tie-rods 10 ft. apart. The flange-way for the wheels is made with granite block toothing in asphalt streets, and brick in brick-paved streets. In unpaved streets the standard construction is an 80-lb. T-rail, A.S.C.E. standard, as used on steam roads. Most of the rest of the track consists of 56-lb. and 60-lb. rail. The power supply from the St. Anthony Falls water-power plant [see Abstract No. 2508 (1900)] has had to be supplemented by the aid of the old steam plant to supply the peaks of the load. This plant is not capable of being worked under economical conditions, and the increase in traffic has now made it inadequate. A three-phase steam plant, generating at 3,450 volts, is therefore being erected alongside the water-power plant, which can be operated in parallel with the latter, allowing the water-wheels to run with a constant full load, and making the steam engines do the greater part of the regulation. A 3,500-kw. three-phase General Electric generator is to be used, direct-connected to a vertical Reynolds-Corliss engine by the Allis-Chalmers Company. It is of the revolving field flywheel type, and the specifications require that it should operate for twenty-four hours at the rated load with not more than 30° C. rise above the engine-room temperature, and that at the close of such a test it shall stand a 50 per cent. overload for one hour without more than 42·5° C. rise, the construction being such that with an engine-room temperature of 25° C. the insulation will not be injured by the specified

rise. The engine is to be compound condensing, with 46-in. and 94-in. cylinders respectively, with a 60-in stroke, running at 75 r.p.m. The building will be laid out to contain six of these units, with the capability of indefinite extension. Six Babcock & Wilcox boilers are on order, with coils for superheating, it being intended to superheat to 120° C. Each boiler has 5,500 sq. ft. of heating surface, and is normally rated at about 550 h.p.

G. W. DE T.

1251. *Electrical Equipment of the Providence, Warren, and Bristol Railway.* (Street Rly. Journ. 19. pp. 181–183, March, 1902.)—This section of the New York, New Haven, and Hartford Railway has recently been changed over from steam to overhead trolley. It has been run for about a year from a temporary station adjoining the new power-house, and containing two 500-kw. 550-volt Westinghouse generators, driven by an old mill engine. It is now used only as an auxiliary during the peak of the load. The new power-house is at Warren, about the centre of the line, and will contain, when complete, two 850-kw., 625-volt General Electric generators, direct-connected to cross-compound condensing Greene engines by the Providence Engineering Company. The boiler-house contains ten 200-h.p. Bridgeport return-tubular boilers, in two batteries. The fire-boxes have steam-jets for burning slack from the engines of the steam section of the line. The Holly gravity system is employed. No separators are employed, extra large curved copper leads being used between the boilers and the main headers, entering the latter from below, while the centre of the engine cylinders are above the water-line in the boilers, the pressure in which is 120 lbs. Dean jet condensers are used. The feeder system is in four sections, so that those nearer the power-station may be run on the 550-volt generators during the load peaks. There is also at each end of the line a 250-cell battery of 800 ampere-hour capacity, made by the Electric Storage Battery Company of Philadelphia. The permanent way has gravel ballast with 70-lb. T-rails of standard A.S.C.E. section, bonded by Washburn & Moen crown pin bonds of the leaf type. Both span and bracket suspension are employed. The old stations are still used, but a number of stops at road-crossings have been added. In spite of this, the schedule time has been improved, for the local trains from Providence to Fall River, from 48 minutes with 14 stops, to 45 minutes with 26 stops, and an express service added, making the run in 33 minutes with 7 stops.

G. W. DE T.

1252. *The Great Northern and City Electric Railway.* (Street Rly. Journ. 19. pp. 200–207, March, 1902.)—This article contains a very full description of the tube-construction work for this railway with illustrations, including drawings showing details of one of the Greathead shields designed for this work by E. W. Moir, a director of the firm of S. Pearson & Sons, the contractors. A brief description is also given of the power-station and of the electric plant to be installed. The line is about 6,200 yards in length, mostly tunnel. The tube is 16 ft. in diameter, except at Moorgate Station, where it is increased to 23 ft. A novelty in construction, introduced after the commencement of the work, consists in making the upper half only of the tube of the ordinary cast-iron segments, the lower half being constructed of Brindle brickwork 15 in. thick, of bricks capable of sustaining a pressure of 400 tons per sq. ft. A cast-iron bearer plate is placed on the line of contact between the cast-iron segments and the brickwork, so as to distribute the pressure equally over the latter. All the machinery required in the construc-

tion has been run by means of 20-h.p. Westinghouse 4-pole motors driving a line shaft to which the various machines were belted. The motors were run upon loose pulleys and put on to the shafting as required. The electric power was obtained from the local supply companies. G. W. DE T.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

1253. *Vibration on Tube Railways.* (Engineer, 93. p. 198, Feb. 21, 1902.)—This is the report of a committee composed of Rayleigh, J. W. Barry, and J. A. Ewing addressed to the President of the Board of Trade. A number of witnesses deposed to the annoyance caused by the vibration due to the working of the traffic on the Central London Railway. The committee satisfied themselves that this was the case. A very little experience showed that the disturbances due to successive trains were very unequal, and, as the result of some elaborate observations, the conclusions were arrived at (*a*) that it was a matter of chance whether a given train caused a slight or a severe vibration; (*b*) that trains causing a severe disturbance in one house were as likely as not to cause only slight vibrations in the others; (*c*) that different rooms in the same house were not similarly affected by the same train. In addition, A. Mallock, who was concerned in the details of these investigations, also made observations on the Waterloo and City Railway, the Metropolitan, and a portion of the Great Western Railway. One of the most distinct indications from these records was the responsibility of the locomotive, as distinguished from the coaches, for the worst part of the disturbances, and the attention of the committee was called to the excessive load, unrelieved by springs, carried on each axis of the locomotives. This and the want of rigidity in the rails is the probable cause of the vibration. New types of locomotives were ordered by the railway company in which the unspring-borne part of the load was reduced. In the case of new locomotives, gearing has been introduced, so that the electric machinery is no longer mounted directly on the driving axles. The unspring-borne load is hence reduced from 8 to 2½ tons on each axle. Motor cars have also been built in which the unspring-borne load on each axle of the truck is under 1¾ tons. With both of these, observations show much less vibration. The committee are hence confident that by adopting motor cars in place of the original locomotives the vibration can be reduced so that no serious annoyance may be caused. On the best form of rail and sleeper they have no decisive evidence. They are disposed to prefer a stiffer rail than that in use on the Central London Railway. W. W. H. G.

1254. *Inertia of Rotating Parts of a Train.* **N. W. Storer.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 153–156, Feb., 1902.)—The author examines the effect of inertia of the wheels and motors of a car, and calculates that for a car weighing 30 tons when loaded, and having eight wheels and two motors of, say, 150 h.p. each, the effect will be equivalent to an increase of the mass of the car by about 10 per cent. H. R. C.

1255. *High-speed Electrical Railways.* **L. v. Reymond-Schiller.** (Zeitschr. Elektrotechn., Wien., 20. pp. 93–99, Feb. 23, 1902.)—In this article, which forms part of a series [see Abstract No. 2306 (1901)], the influence of the air resistance is discussed, and various formulæ are quoted. The effect

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

of the shape of the front of the autocar is also considered. Finally the tractive force is calculated for a train of 200 seats, run at various speeds on lines of different gauges, and it is shown that the broad gauge of 4 m., previously decided upon, is necessary for economical working, especially at the high speed of 250 km. an hour. W. W. H. G.

1256. *Three-phase Traction System.* **M. Fabre.** (Elektrotechn. Zeitschr. 23. pp. 120–121, Feb. 6, 1902.)—The author shows that with the Ganz system, and the series connection of the induction motors at starting and stopping, the energy recovered by using the motors as brakes may amount to as much as 66 per cent. of the energy wasted in the rheostats at starting. A. H.

1257. *Mechanical Efficiency and Mileage of Electric Automobiles.* **H. W. Alden.** (Elect. World and Engineer, 39. p. 301, Feb. 15, 1902.)—The author has embodied in the accompanying curves data accumulated in the course of several years' experience with respect to the effect of the mechanical efficiency, that is, of motor efficiency and of gearing, bearing and tyre losses. The miles travelled are taken as ordinates, and as abscissæ the values of the energy W in watt-hours required to propel 1,000 lbs. one mile, so that W is determined by the formula—

$$W = \frac{\text{Watts expended}}{\frac{\text{Weight of Vehicle}}{1000}} \times \text{Speed in miles per hour.}$$

In the calculations, each set of determinations was so made that the vehicle speed corresponding to a certain assumed expenditure of energy corresponds

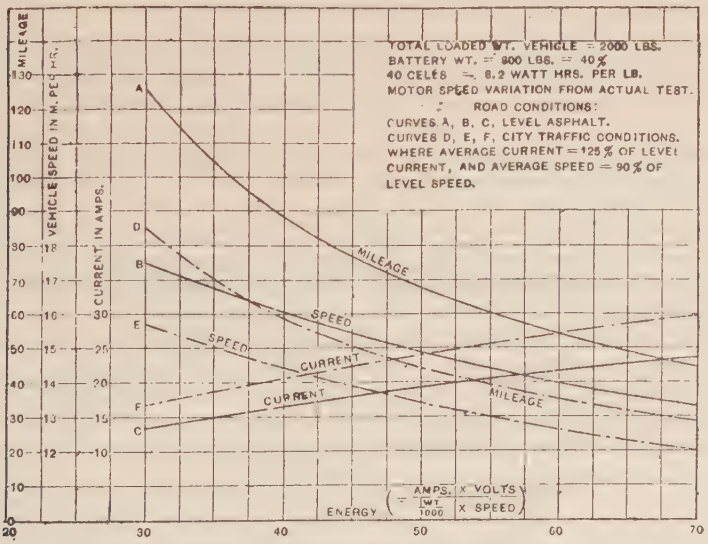


FIG. I.—SPEED, CURRENT AND MILEAGE CURVES.

exactly to the motor speed at that current, the variations in motor speed being taken from actual tests. In Fig. 1 the continuous lines represent results obtained on level asphalt or macadam, the dotted lines those obtained in congested city traffic and cross-country work. The increase in current

and reduction in speed under the latter conditions have been found to average 25 and 10 per cent. respectively. The battery capacity has been taken as a variable, depending on the discharge rate, and the range of energy from 80 to 70, the former representing a very low commercial figure, and the latter a prohibitively high one. It will be noticed that a decrease in energy from 60 to 30 increases the mileage from 54 to 126, or 2·33 times. The curves in

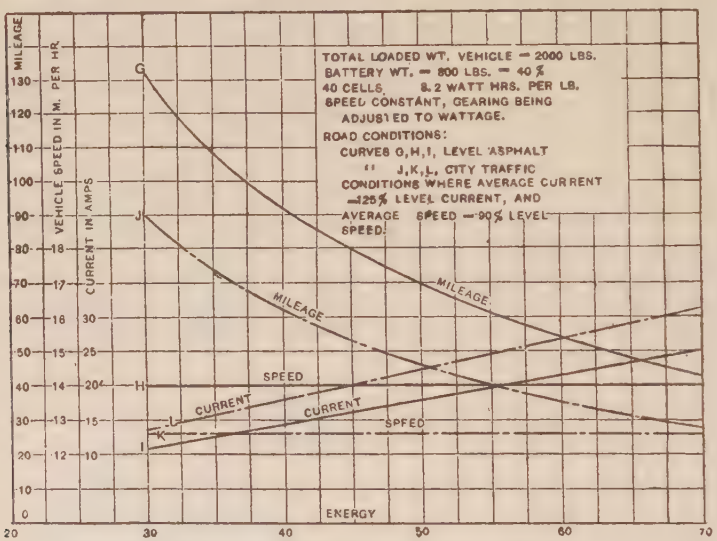


FIG. 2.—SPEED, CURRENT AND MILEAGE CURVES.

Fig. 2 have been obtained in the same manner, except that for each variation of energy the gearing or motor-speed has been assumed to be altered so as to maintain a uniform speed of 14 miles an hour. The main difference in resulting mileage is that the mileage mounts up faster in proportion to the decrease in energy, the mileage increase, for an increase of energy from 60 to 30, being from 53 to 133, or 2·51 times. G. W. DE T.

1258. *Cast Zinc Rail-Joints.* (Street Rly. Journ. 19. pp. 173–177, March, 1902.)—This joint was invented recently by the engineers of the Union Traction Company of Philadelphia, and it has proved so successful that the company is now using the joint to a considerable extent. Two angle plates are made to fit the web of the rail closely, and overlap the wire, except that a space of about $\frac{3}{16}$ in. is left between the head and the base of the rail and the flanges of each of the angle plates; these are then riveted through the web of the rail by twelve 1-in. rivets, set up by a pneumatic riveter, and zinc is poured into the intervening space. G. W. DE T.

1259. *Rail-Rolling at Lower Temperatures during* 1901. **S. S. Martin.** (Railroad Gazette, 34. pp. 1–2, Jan. 3, 1902.)—It is generally known that the non-granular structure of light rails, caused by their being finished at a low temperature, ensures longer and better wear than anything offered by the heavier sections, but it is, nevertheless, only just recently that manufacturers have begun to roll the heavy rail at anything approaching the low temperature used for the other kind. To obtain a non-granular structure it is requisite that the reduction in temperature should take place earlier than has been

heretofore customary, the bar or bloom being rolled direct from the ingot. This would mean delivery of the bloom to the rails at a temperature of 800° C. in place of the 1,000° C., or more, of the reheated bloom. It is important to note that, whilst a rail is held before the final pass at a temperature beyond the critical point it crystallises, and the single pass it afterwards receives is unable to break up the granular structure for more than a certain depth. The method, just introduced, of holding the bar before the last pass, has greatly improved the structure, but even this is not so homogeneous as a structure obtained by direct rolling, the temperature being too much above the critical point, and the steel consequently granulating too easily whilst being held for the cooling before the final pass. Undoubtedly the most satisfactory way of investigating this question of rolling is by means of the microscope. It is thus shown that, to obtain the best structure throughout, the bar must be kept at a lower average temperature. Regarding shrinkage, it is emphatically stated to be not in the least degree helpful or indicative of the construction.

C. E. A.

ELECTRIC LAMPS AND LIGHTING.

1260. *Electric Illumination.* **L. Bell.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 93–115, Feb., 1902.)—In this paper the physiological and physical aspects of lighting are fully discussed. As regards steadiness, the author considers that an alternating current arc worked with a small current density requires a minimum frequency of 100 ∿ per second, the minimum frequency for incandescent lamps being 35 ∿ per second. As regards the intrinsic brilliancy of the radiant employed, the author considers 5 c.-p. per sq. in. as high as it is wise to go for hygienic reasons. When using diffusing globes to reduce the intrinsic brilliancy, the radius r of a spherical globe may be determined from the formula—$r = \text{c.p.}/5\pi$. The author advocates enclosed continuous-current arcs taking 6·5 to 6·75 A. to replace the usual 2,000-c.p. arcs. The colour of light, photometric standards, arrangement of lamps, and other general questions are also discussed.

C. K. F.

1261. *The Benard Enclosed Arc Lamp.* **J. A. Montpellier.** (Électricien, 23. pp. 65–67, Feb. 1, 1902.)—In this lamp, in order to avoid shadows, the lower carbon is held in a metal socket secured in the lower end of the inner globe, the current being supplied thereto by an external wire of small diameter. The feed-mechanism comprises a central core movable in the regulating solenoid and serving as the upper carbon holder. The brake consists of a steel knife for acting on the upper carbon. This knife is carried by a lever pivoted at one end to the core of the regulating solenoid, and at the other end to a vertical rod passing through a guide eye or collar which can be adjusted vertically on the frame of the lamp to vary the length of the arc. This rod bears a spring below the collar and nuts above it for regulating the tension of the spring. The lamps burn with currents of 1·5, 2, and 2·5 amperes for the small size; and 3, 4, 5, and 6 amperes for the large size. The potential difference between the carbons is preferably from 75 to 80 volts.

C. K. F.

1262. *The Nernst Lamp.* **A. J. Wurts.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 254–270, March, 1902; Discussion.)—The discussion elicited the following facts. Filaments can be made from a variety of substances, but the most refractory substances cannot be used, owing to the fact that they

require a large steadying resistance, and are electrically unstable. The curve for such filaments shows that they would have to be worked at a point where the voltage decreases with increasing current, and their commercial efficiency is small. The platinum used in a 6-filament lamp, as made in America, costs about 92 cents. On direct-current, lamps usually break at one of the terminals, where platinum black is deposited in the pores. In America no attempts have yet been made to produce a lamp of less than 50-c.p. ; lamps of 25-c.p., made in Germany, are said to be too delicate for ordinary use. The nature of the black deposit on the filament, when worked with direct-current, is not very certain, but it is believed to be platinum black. The filaments are run at a temperature of about 2,500° C. Irrespective of the discoloration of the globes and porcelain parts of the lamp, the candle-power given out by the filament decreases by about 3 per cent. in the first 100 hours ; but this loss is small compared with the loss in the lamp when it is neglected and not properly cleaned. The shrinkage of the filament has been provided for by making it U-shaped. A life of 300 hours has been obtained with filaments lighted by direct current, and it is possible that this may eventually be increased to 500 hours. The Nernst lamp burns well on 25 cycles, and no difference is noticeable between 25 and 60 cycles. The cut-out is, however, apt to rattle on the lower frequency. If a filament is too long and heavy, it will sag at the running temperature ; but if properly proportioned, it will remain almost perfectly straight. [See also Abstract No. 2312 (1901).]

W. H. S.

REFERENCES.

1263. *Gmünd Electricity Works.* **E. v. Rziha.** (Zeitschr. Elektrotechn., Wien, 20. pp. 46–49, Jan. 26, 1902.)—Description of a small station worked by gas engines, supplied with Dowson gas, and containing two 40-kw. dynamos. W. H. S.

1264. *Cost of Tramway Construction in France.* (Tram. Rly. World, 11. pp. 19–22, Jan., 1902.)—This paper consists of valuable tabulated data relative to the construction costs of French tramways. The systems considered are : Horse traction ; Rowan, steam ; Serpollet, steam ; Compressed Air ; Hot Water Engine (Lamm and Francq system) ; Accumulator ; Overhead Wire ; Conduit ; and the Diatto and Claret-Vuilleumier surface-contact systems. G. W. DE T.

TELEGRAPHY AND TELEPHONY.

1265. *Gruhn's Telautograph.* **Gruhn.** (Elektrotechn. Zeitschr. 23. pp. 117–119; Discussion, pp. 119–120, Feb. 6, 1902. Paper read before the Elektrotechn. Verein, Dec. 17, 1901.)—In this apparatus the arrangement for resolving the motion of the writing pencil into two components is similar to Gray's. In the new apparatus, however, direct currents varying continuously in strength in proportion to the distance of the pencil-point from each edge of the writing surface are employed. This is effected by two regulating resistances which are both connected across the terminals of a battery having one pole earthed. Over each of these resistances slides a contact which receives one component of the motion of the pencil through a connecting rod, and is connected to one of the two line wires. The receiver consists of a mirror which can oscillate in two directions at right-angles to each other, and controlled by two electromagnets, one for each line wire. This mirror reflects a ray of light from a glow lamp on to a sensitised band of paper. The operation is as follows: As soon as the sender has grasped the pencil the battery at the transmitting station is automatically switched into circuit, and the glow lamp at the receiving station, with its battery, switched into circuit through a relay. When the sender returns the pencil to its position of rest the same relay extinguishes the glow lamp and sets the electromotor in motion to feed the sensitised paper bearing the record out of the box through a developing and fixing tank. The motor automatically switches itself out of circuit when the required length of paper has been fed. In order to prevent successive words from being connected by a useless line the following arrangement is adopted, viz.: On the pencil of the transmitter is mounted a switch, which is closed when the pencil is pressing on the writing surface, and is open when the pencil is raised. Through this switch flows one "component" current, and as soon as this current is interrupted the beam of light at the receiver moves rapidly to the edge of the writing surface, and thus there is no photographic print. When the pencil again presses on the writing surface the switch is closed and the beam of light returns to its correct position. By making the apparatus with a resistance of 6,000 ohms the influence of the resistance of the line in reducing the size of the record at the receiver is rendered negligible. The motor for effecting the paper-feed at the receiver will work with a current of 0·2 amperes at 4 volts, which is supplied by dry batteries. These batteries also supply the glow lamp. In the discussion **von Hefner-Alteneck** pointed out that the receiver was very similar to the Pollák-Virág apparatus, and expressed doubts as to the suitability of the apparatus for use on very long lines, as did **Strecker.**

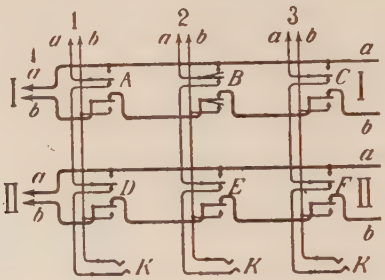
C. K. F.

1266. *Wireless Telegraphy. German Post Office Test of Braun's System.* **Jentsch.** (Archiv Post Tele. 24. pp. 763–766, Dec., 1901.)—Description of an experimental installation between Cuxhaven and Heligoland. The transmitter gives out trains of waves of a definite frequency to which the receiver is also tuned by suitable capacities and self-inductions. The aerial wire is one quarter wave-length.

Good results were obtained with a 40 m. aerial. The coherer was one of

Siemens and Halske's with steel electrodes and steel filings. Very satisfactory results were obtained, the speed being about seven words per minute.
J. E.-M.

1267. *Janus Telephone Exchange System.* **H. Zopke.** (Elektrotechn. Zeitschr. 23. pp. 151–157, Feb. 20, 1902.)—This system enables the instruments of a private network, such as that in a large manufactory, to be also used as postal exchange instruments. It consists of a non-automatic secondary exchange, the connections being as follows: I *a b* and II *a b* are the postal lines, and 1 *a b*, 2 *a b*, 3 *a b* the private lines; A, B, C, . . . are Janus switches,



the spring tongues of which are displaced outwardly by a conical insulating plug mounted on a spindle which moves in guides, and is provided with a handle; this spindle is provided with a bayonet-fastening or like-locking device so as to enable the tongues to be held in their outward positions as at B. K, K are the ordinary jacks for the private exchange. This type of switch is modified when there are a large number of postal lines, in which case the conical plug is actuated by a crank-arm. A somewhat similar switch is used for connecting the calling-up apparatus either to the postal lines or to the private lines as required. Full diagrams are given of the connections of all the apparatus, together with its method of operation and its application to several cases. It is made by Messrs. Mix & Genest, of Berlin. C. K. F.

REFERENCES.

1268. *Wireless Telegraphy.* **A. Slaby.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1047–1055, July 27, 1901. Abstract in the Electrician, Aug. 23, 1901.)—The paper contains a description, in popular form, of Marconi's and other systems of wireless telegraphy. Some modifications introduced by the author are described in detail.
J. E.-M.

1269. *Wireless Telegraphy.* **F. Braun.** (Phys. Zeitschr. 3. pp. 143–148; Discussion, p. 148, Jan. 1, 1902. Paper read before the 73rd Naturforscherversammlung at Hamburg, Sept. 24, 1901.)—A discourse on wireless telegraphy, illustrated by experiments.
E. H. B.

1270. *Automatic Telephone Exchange at Fall River.* (Elect. Rev. N.Y. 39. pp. 604–606, Nov. 16, 1901.)—Description of the Automatic Telephone Exchange at Fall River, Mass., U.S.A.
J. E. K.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JULY 1902.

GENERAL PHYSICS.

1271. *Mercury Pumps.* **F. Neesen.** (Ann. d. Physik, 7. 3. pp. 693–697, March, 1902. Also Deutsch. Phys. Gesell., Verh., Feb. 7, 1902.)—In this paper, the author criticises the results obtained by G. W. A. Kahlbaum [see Abstract No. 1 (1902)], on the ground that the McLeod gauge was arranged near the air-pump instead of beyond the receiver. The author then describes some experiments he has made to compare Kahlbaum's pump with two single piston pumps and one double piston pump. Instead of using a McLeod gauge, six definite, luminous effects, successively obtained in a Crooke's or X-ray tube during exhaustion, are used as standards. With the double-piston pump, the X-rays appeared after 9·5 minutes pumping. This pump has a continuous action, and is provided with special valve-gear in which one "boot" empties whilst the other fills, the mercury running in from above.

C. K. F.

1272. *Recorder for Soundings.* **C. Bamberg.** (Zeitschr. Instrumentenk., Beib. 4. pp. 33–34, Feb. 15, 1902.)—This is a pneumatic sounding apparatus, consisting of a glass tube closed at the top by a metal cap, through which passes a capillary tube. The lower end of the glass tube is conical, and can be closed by a valve. The apparatus is protected by a casing of metal, through which holes are bored so as to give free access for water. A gauze is provided to exclude foreign particles from the capillary. This apparatus is intended to be used with a sinker, the depth being assumed proportional to the quantity of water which passes by way of the capillary into the glass tube. The glass tube is graduated to 200 m.

R. A.

1273. *Dilatometer for extremely-dilute Solutions.* **F. Möller.** (Ann. d. Physik, 7. 2. pp. 256–284, Feb., 1902.)—The dilatometer measures the change in volume which accompanies the solution of acids or the further dilution of solutions. It was designed by the author on the suggestion of W. C. Röntgen, and is made by C. Kramer, of Freiburg, in Baden. A cylindrical glass vessel, 350 c.c. capacity, is fitted with a glass dome and a calibrated capillary. In the upper portion is suspended a tray to receive the substance; this tray is lowered by withdrawing a pin of iron, enclosed in glass, from outside with

the aid of an electromagnet. The whole apparatus fits into a brass cylinder, and is kept in a water bath from which the capillary projects, and in which the apparatus is oscillated about its vertical axis. The vessel is almost filled with water, the upper portion and the capillary with petroleum. Corrections have to be made for the hydraulic pressure of the petroleum column, the wetting of the capillary by the petroleum, and the cooling which the liquid undergoes while the substance is being dissolved. These features are discussed in detail. An experiment with sodium chloride takes two minutes; very satisfactory results were obtained. H. B.

1274. *Strain produced by Gelatine.* **L. Cailletet.** (Comptes Rendus, 134. pp. 400–402, Feb. 17, 1902.)—A thick coating of strong glue spread upon glass splits off when it dries, pulling with it lamellæ of the glass, and leaving a decorative curved pattern, which is more remarkable if crystalline salts, say 6 per cent. of potash alum, are added to the glue. A cylindrical vase of thin glass so treated will split up into a hemi-cylinder; and a thick piece of glass will, under polarised light, show the contractile strain to which it is subjected. A. D.

1275. *Stresses in Plates subjected to Water Pressure.* **J. G. Boobnoff.** (Engineering, 73. pp. 390–392, March 21, 1902. Paper read before the Institution of Naval Architects.)—The outer and inner bottom plating and the bulkhead plates of a ship generally present a series of flat plates fixed to a rectangular network, and subjected to the water pressure; this pressure may be regarded as uniform for each individual rectangular plate. It is important in naval architecture to determine the relation between the water pressure, the dimensions of the plate, and the stresses produced in it. All attempts to solve the question theoretically proceed either on the assumption that the plate is absolutely stiff, or that it is absolutely flexible. The formulæ deduced on the latter assumption are in better accord with the results of experience, though it is obvious that the assumption is incorrect. The author assumes neither absolute stiffness nor absolute flexibility, and though he cannot give a definite solution he endeavours to establish the limits between which lies the tension on a flat plate of given dimensions loaded with a certain pressure; he then applies his results to the construction used in merchant vessels and in warships. A plate whose boundary is fixed resists pressure partly by its stiffness, partly by its stretching. First, therefore, the author considers the two limiting cases of the flexion of a stiff beam and the resistance of a perfectly flexible elastic chain. For a long beam supported at the ends and uniformly loaded it is well known that up to a certain limit, the strain at any point varies as the load, as also does the stress at that point; beyond that limit the strain increases faster than the load, while the stress varies almost proportionally to the load, and the beam finally breaks at its weakest part. For a chain of negligible mass stretched horizontally between two fixed points, the deflection varies as the cube root of the load, while the tension varies as the two-thirds power of the load; beyond the limits of perfect elasticity the deflection at any point increases more rapidly than before, the tension more slowly; those departures from uniformity are considerable, and the formulæ applicable to a perfectly elastic chain give neither the magnitude of the deflection nor that of the tension just before the chain breaks. In an Appendix (not reproduced in *Engineering*) formulæ are given for determining the stresses in the chain corresponding to different loads in the cases where the chain is made of ideal perfectly elastic material and of real imperfectly

elastic substance ; in the latter case the strains and stresses increase more slowly than the load up to the limit of proportionality, beyond that the strains increase faster than before and the stresses more slowly. The usual criterion of a factor of safety is here quite inadmissible ; if a load of six tons (to take a particular chain) breaks the chain, a load of one ton produces a tension of four-sevenths of the ultimate tensile strength. The most important case in shipbuilding practice is that of a rectangular plate firmly rivetted to a frame which may be regarded as rigid, and in this case the plate represents something intermediate between the stiff beam and the flexible chain ; if the tensions are small it closely resembles the stiff beam, while if they are large the chief part of the resistance of the plate is due to its extension, as in the chain. The ratio of the least dimension of the plate to its thickness determines whether the first or second case gives a closer approximation ; for Seimens-Martin steel when the ratio is 20 or less, we have the first case, and when it approaches 1,000 we have the case of the chain, while for plates of medium thickness (ratio 50 to 200) the flexion is markedly different from that in the extreme cases. A table is given to illustrate this. Beyond the limit of elasticity the formulæ of the Appendix gives tensions greater than the true ones. The author considers next the cellular-bottom construction, in which the rectangular plates are not merely supported, but must be regarded as built in ; he shows that if the limit of elasticity be exceeded at the built-in edges, the plate becomes a supported plate, and never regain its initial condition. The formulæ given in the Appendix enable us to calculate the limiting value of the pressure producing a permanent set of the plate, but the exact value of the breaking pressure cannot be found. The author then goes on to consider numerical values of the various quantities as they occur in marine practice, and proposes on the basis of his results a method for constructing the hull of a ship, so that the tension in the inner bottom plates when exposed to the pressure due to the test column of water (whose height must be not less than the draught of the vessel) shall not exceed the practical admitted limits, and that the tension in the outer shell plating due to the same pressure shall be as small as desired. W. S.

1276. *Vibrations of Two Pendulums of nearly Equal Periods on a Common Support.* **P. Furtwängler.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 12. pp. 245–253, Feb. 27, 1902.)—The knife-edges of the pendulums are parallel, the amplitudes small, and the supporting surface is assumed to experience horizontal parallel elastic displacements, whose magnitude is directly proportional to the sum of the horizontal forces exerted by the pendulums on the support. The author solves the equations of motion by introducing two complex quantities whose moduli represent the instantaneous amplitudes and arguments the phases of the two pendulums. If V_1,V_2 are the increases in period of the pendulums due to co-vibration of the support, then the ratio $V_1 : V_2$ is known, being $M_1h_1/T_1^3 : M_2h_2/T_2^3$ where M_1,T_1 are the masses and periods of pendulums and h_1,h_2 the distances of their centroids from the axes of rotation ; in order to determine the influence of the co-vibration either V_1 or V_2 must be found. The author deduces from his results four methods of obtaining V_1 or V_2 by observation of amplitudes ; three of those are virtually the same as those employed by v. Orff, Lorenzoni, and Schumann, Kühnen, and Borrass, while the last seems to be given for the first time and is applicable only to the case in which the pendulums have equal damping coefficients. He gives also a method which depends on observation of periods and which he has found easy to carry out. In the practice of this

method (in which the damping coefficients and periods must be nearly equal) the pendulums are made to vibrate (1) with phases almost the same, (2) with phases almost opposite ; the periods and mean phase differences are observed in the two cases. Then if t_1, t_2 and $1 - \epsilon$ are the periods of the pendulums and the cosine of the mean phase-difference in the first case, $t_1 - \delta_1$, $t_2 - \delta_2$ and $-1 + \zeta$ the same quantities in the second it is shown that—

$$\sqrt{V_1 V_2} = (\delta_1 + \delta_2)/2(2 - \epsilon - \zeta).$$

Since V_1/V_2 is known, V_1 and V_2 can be found. The case of opposite phases corresponds to a method proposed by Faye for eliminating the co-vibration (Faye's double pendulum). W. S.

1277. *Forced Oscillations.* **E. Riecke.** (Phys. Zeitschr. 3. p. 180, Jan. 1, and pp. 201–202, Feb. 15, 1902.)—These are mathematical papers dealing with the oscillations of a light pendulum which is suspended from the heavy bob of another. R. S. W.

1278. *Density and Surface-Tension of Liquid Air.* **C. T. Knipp.** (Phys. Rev. 14. pp. 75–82, Feb., 1902.)—In order to investigate the surface-tension, knowledge must first be obtained as to how the density of the liquid varies with the time that has elapsed since its manufacture. This is done by the sinker method, and a curve is plotted giving density at any time. From this it is deduced that the density of freshly made liquid air is 0·933, and thereafter it increases until it reaches practically the same value as liquid oxygen. The surface-tension is investigated by the capillary tube method and also by weighing a mica frame in it. The final results show that the surface-tension of fresh liquid is between 9 and 10 dynes per cm., rising after several hours to a constant value of about 13·4. R. S. W.

1279. *Molecular Fields of Force.* **S. Leduc.** (Comptes Rendus, 134. pp. 423–425, Feb. 17, 1902.)—The application of the notion and of the mode of representation of the fields of force of Faraday to the molecular movements which take place in liquids permits the explanation of a great number of phenomena. In the case of a drop of any aqueous solution in the midst of a mass of distilled water the dissolved molecules extend by diffusion in all directions, the water moves in an opposite direction to replace them ; the drop is then the seat of a field of force ; the directions followed by the moving molecules being lines of force of this field. Similarly a field of force of crystallisation is got when a crystal forms itself in a solution. The dissolved molecules direct themselves to the crystal from different points of the solution, and a motion of the water in a contrary direction takes place. The case is the inverse of diffusion and the crystal is the focus of a field of force whose lines of force are the directions followed by the moving molecules. By making the molecular movements more slow by a colloid substance such as gelatine and drying rapidly the liquids operated upon, the matter has been arrested during the process of diffusion or crystallisation, and photographs of the molecular fields of force have been obtained. Examples of interference between fields of force of diffusion, or between fields of force of diffusion and crystallisation, are exhibited on some of the photographs. J. J. S.

1280. *On Universal Vibrations of Matter.* **A. Korn.** (Comptes Rendus, 134. pp. 31–33, Jan. 6, 1902.)—The principle enunciated in this paper

rests on Bjerknes' experiments, and has for its object the substitution for direct action between distant bodies of mechanical forces propagated continuously through space. Ponderable matter is supposed to consist of slightly compressible particles, suspended in an infinite and theoretically incompressible ether. Such a system admits of many vibrations, capable of superposition, having periods T_0 T_1, &c., in decreasing order. Vibrations of order zero lead to the Newtonian law of attraction. Those of the first order to friction between neighbouring particles of continuous matter, which explain Maxwell's law of repulsion in gases. Vibrations of the second order lead to capillary forces, and so on. He propounds the question whether a system in which the velocities at any point in space of the above described particles are $u = U \sin \frac{2\pi t}{T}$, $v = V \sin \frac{2\pi t}{T}$, $w = W \sin \frac{2\pi t}{T}$, U V W being unknown functions of position, is possible. The condition that it shall be possible is that U V W are derived from a potential ϕ which satisfies $\Delta\phi = 0$, in free space, and $\Delta\phi + k^2\phi = 0$, in the interior of the particles. S. H. B.

1281. *Stability of a uniformly Rotating System.* **P. Duhem.** (Comptes Rendus, 134. pp. 23–24, Jan. 6, 1902.)—In a former memoir (Comptes Rendus, April 29, 1901), the author found a criterion of stability subject to the condition that the moment of momentum about the axis is unchanged. In the present paper he gives a criterion for a more general case as follows: If M_0 be a value of the moment of momentum, M any other value very near to M_0, then if certain conditions are fulfilled the equilibrium with M_0 is stable, even for disturbances which do change M. The conditions namely are (1) that for each value of M there corresponds a state of equilibrium E, in which the sum $F + \Omega + W$ in the notation of the former paper is a minimum, given M constant; (2) E varies continuously as M varies continuously. The expressions "continuously" and "minimum" require definition as follows: Suppose dm an element of mass, and let α_0, β_0, &c., be the variables which define its condition in the state of equilibrium E_0 of the system, α, β, &c., the corresponding variables for the state E of equilibrium, then the state E_0 is infinitely near to the state E when $\alpha - \alpha_0$, $\beta - \beta_0$, &c., are infinitely small for every element dm of mass, except for a certain number of such elements whose sum is infinitely small. S. H. B.

1282. *Boundary Conditions in Hydrodynamics.* **P. Duhem.** (Comptes Rendus, 134. pp. 149–151, Jan. 20, 1902.)—In the determination of the boundary conditions between fluid and solid, or two fluids, the author has in former works employed the principle of viscosity and the principle of friction. To the virtual work done we have to add the virtual work $d\mathfrak{T}_w$ of viscosity at contact, and $d\mathfrak{T}_\psi$ of friction at contact. And the author puts these in the form—

$$d\mathfrak{T}_w = \int f v' \partial r dS \qquad d\mathfrak{T}_\psi = \int G \frac{r'}{(r')} \partial r dS$$

in which r' is the relative velocity of two particles, one taken from each of the bodies in contact. Here f and G are essentially negative, f is a function of r', of T the temperature at the point of contact, and of ρ_1, ρ_2 the densities in that neighbourhood. Also dS is an element of the interface. If ∂x_1, ∂y_1, ∂z_1 be the virtual displacements of one particle, ∂x_2, ∂y_2, ∂z_2 those of the other, and if l, m, n be the direction constants of the normal to the interface, the condition—

$$l(\partial x_1 - \partial x_2) + m(\partial y_1 - \partial y_2) + n(\partial z_1 - \partial z_2) = 0$$

must be fulfilled. We must, therefore, add to the expression for virtual work the term—

$$w\{l(\partial x_1 - \partial x_2) + m(\partial y_1 - \partial y_2) + n(\partial z_1 - \partial z_2).$$

G is then a function of T, ρ_1, ρ_2, r' and w. He finds that if one body be a solid, then at every point on the interface—

$$l(\Pi - w) - p_{x1} = \left(f + \frac{G}{(r')}\right)(u_1 - u_2)$$

with two analogous equations, in which Π is the pressure, p_{x1}, p_{y1}, p_2 are the components of the "fictive" pressure of viscosity. This determines w. It is necessary in certain cases to assume adhesion between solid and fluid.

S. H. B.

1283. *Certain Cases of Adhesion of a Viscous Liquid.* **P. Duhem.** (Comptes Rendus, 134. pp. 265–267, Feb. 3, 1902.)—This note refers to the previously mentioned case in the preceding memoir [see Abstract No. 428 (1902)] where there is adhesion between solid and fluid. He gives first the condition that the fluid may be incompressible and of uniform temperature, and supposes next the solid to have a motion of simple translation. The problem then is, given a solid cylinder of revolution about an axis parallel to z, moving with uniform velocity U in direction x, and given that it is moving in a fluid whose component velocities are u v. Then the motion of the fluid is stationary with regard to axes attached to the cylinder, if u v are functions of $x - Ut$, y. If l be the distance from the origin to a point in the plane of x y, then condition (3) lu, $l^2\frac{du}{dx}$, and $l^2\frac{du}{dy}$ do not increase without limit as l increases without limit, and the same is true of lv, &c. The equations of motion are, then, after Navier—

$$\frac{\partial \Delta}{\partial x} + (u - U)\frac{\partial u}{dx} + v\frac{\partial u}{\partial y} - \frac{\mu}{\rho}\Delta u = 0$$

&c., where Δ is a function of z. The object of the present note is to show that such a state of things cannot exist unless $U = 0$. By the equation of continuity $\frac{du}{dx} + \frac{dv}{dy} = 0$, there must therefore exist a function $\phi(x - Ut, y)$ such that $u = \frac{d\phi}{dy}$, $v = -\frac{d\phi}{dx}$. Hence he proves that $\Delta\phi = 0$, whence it follows that $u = 0$ $v = 0$. He supposes, in conclusion, a liquid of infinite extent in height and depth bounded by a cylindrical surface parallel to z, the velocities are independent of z. The liquid is infinitely extended, while the conditions (3) that lu, $l^2\frac{du}{dx}$, &c., remain finite while l is increased indefinitely, are maintained. Then if the liquid adheres to the solid, there can be no permanent state except that of equilibrium.

S. H. B.

1284. *The Impossibility of Certain Permanent States in Viscous Fluids.* **P. Duhem.** (Comptes Rendus, 134. pp. 456–458, Feb. 24, 1902.)—It might be inferred from the paper considered in the preceding Abstract, the author says, that in such permanent states the fluid does not adhere to the solid. He puts a case to show that the inference is erroneous, the method used being that of Poincaré and Zaremba. There are two impossible cases, namely—1. A liquid is contained between two parallel planes of which one is at rest, and the other slides with uniform velocity parallel to itself, the liquid in the

permanent state moves by layers parallel to the direction of that motion. 2. A liquid is contained between two cylinders of revolution about the same axis of indefinite extent, each cylinder having a uniform velocity of rotation about the axis. In the permanent state the liquid revolves in circles round the axis. The impossibility admits of three interpretations: *First*, That the state supposed cannot be permanent. *Second*, That there is no adhesion between fluid and solid, but only quasi-adhesion when f is very great. *Third*, The equation of motion of a viscous liquid are inconsistent. He proposes to show later which interpretation should be adopted. S. H. B.

1285. *Kelvin's Images and the Equations of Elasticity.* **C. Somigliana.** (Accad. Lincei, Atti, 11. pp. 145–154, Feb. 16, 1902.)—Given an elastic medium symmetrical about the plane $z=0$, the equation of equilibrium are, in the usual rotation,

$$\frac{dX_x}{dx}+\frac{dX_y}{dy}+\frac{dX_z}{dz}=0,$$

with corresponding equations for the Y's and Z's. If $u(x\,y\,z)$, $v(x\,y\,z)$, $w(x\,y\,z)$ are integrals of these equations, then also $\bar{u}=u(x\,y-z)\,\bar{v}=v(x\,y-z)\,\bar{u}=w(x\,y-z)$ are integrals. If then the body be crystalline bounded by $z=0$, and has its planes of symmetry parallel to $z=0$, and if L, M, N be the forces which produce the displacement u, v, w — L_1 — M_1 + N will produce displacements $\bar{u}_1, \bar{v}_1, \bar{w}$. We may now form the new integrals $u_1=u-\bar{u}$, &c., and if $L_1 M_1 N_1$ are the forces which produce them, the conditions satisfied at the boundary $z=0$ are $u_1=0$, $v_1=0$, $N_1=0$.

If we take for new integrals $u_2=u+u$, &c., and corresponding forces $L_2 M_2 N_2$, the conditions are $w_2=0$, $L_2=0$ $M_2=0$—in the one case two tangential components of displacement and the normal component of pressure vanish, in the other two tangential components of pressure and the normal displacement. By this method is solved the following problem, to determine the deformation produced in an indefinite body, bounded by a plane and crystallised with planes of symmetry parallel to that bounding plane, when on that plane are given the tangential components of displacement and the normal pressure. Also the corresponding problem with displacement and pressure interchanged in the conditions for the bounding plane. The calculations are then applied to the case of isotropy. If there be two orthogonal planes of symmetry, for instance $x=0$, $y=0$, and if u, v, w are integrals, the method above indicated enables us to deduce two other sets of integrals.

By a further extension of the method it is shown that a solution may be found of the problem of the deformation of the right diedron, solid and isotropic, so crystallised that the planes parallel to the faces are planes of symmetry, when on one face, *i.e.*, $x=0$ the components L, v_1, w_1, and on the face $y=0$ the components u, M, w_1, are given, that is on both faces the normal pressure and tangential displacements are given. And again the corresponding problem is discussed in which pressures and displacements are interchanged in the face conditions. S. H. B.

1286. *Elastic Equilibrium of Circular Cylinders under Certain Practical Systems of Load.* **L. N. G. Filon.** (Roy. Soc., Phil. Trans. 198. pp. 147–233, Feb. 28, 1902. Roy. Soc., Proc. 68. pp. 353–358, July 9, 1901. (Abstract).)—The writer objects to the solutions usually given for the extension and compression of elastic bars on the ground that they are based on the assumption that the bars are strained under normal tension or pressure uniformly dis-

tributed across the plane ends, and in like manner to the solution for torsion as assuming tangential stresses across the plane ends. These assumptions are not realised in practice. Solutions are given in this paper more in accordance with conditions occurring in practice. The writer first works out the general solution for a symmetrical strain (sections 3 and 4), using cylindrical co-ordinates as in Todhunter and Pearson's history of elasticity. He then applies the method to three problems. The first problem is that of a cylindrical bar of radius a subjected to a determinate system of normal radial pressures and of axial shears over the curved surface, the radial pressures being symmetrical about the mid section, and the shears having their signs there changed. In a subdivision is considered the special case when the pressure is zero. The stresses on the curved surface are calculated and the numerical results discussed—sections 5–11. The second problem is that of a similar cylinder under pressure whose ends are not allowed to expand. And in this relation two methods of constraint are dealt with in sections 12 and 13 respectively. First method—(1) There is no shear $\overline{rz}$ along the curved surface $r = a$. Over two rings of breadth e at the ends a radial pressure P is made to act, so adjusted that there is no radial shift at the points A, B, or C, D on the circumference at the respective plane ends. (2) The plane ends AB, CD are constrained to remain plane, and are subject to a total normal pressure $\pi a^2 Q$. The second method of constraint is effected by shear over the terminal cross-sections. In this case (1) there is a total pressure $\pi a^2 Q$ over the plane ends, the distribution being unknown ; (2) the ends are constrained to remain plane ; (3) the ends are not to expand along the perimeter. This condition is satisfied by allowing a shear $\overline{rz}$ over the plane ends. (4) There is no stress across the curved surface. These conditions represent the state of things when the cylinder is compressed between two rigid planes sufficiently rough to prevent expansion of the ends. In section 23 the phenomena attending rupture, the distribution of maximum stress, strain and stress difference are considered. It is found that whatever theory of yielding be adopted, viz., the greatest stress theory of Navier and Lamé, the greatest strain theory of St. Venant, or the greatest strain difference as recently put forward, failure of elasticity will begin to take place round the perimeter of the plane ends. The values of the apparent Young's modulus and Poisson's ratio are here discussed. It is inferred from the numerical calculations given that plastic deformation begins to occur round the perimeter for a stress between $\frac{2}{3}$ and $\frac{1}{2}$ of that which is required to cause a cylinder under uniform pressure to pass the elastic limit. The third problem is that of torsion. The cylinder is supposed subject to a certain series of transverse surface shears. A special case is considered where there are two discontinuous rings of shear. The general results obtained indicate that as we go away from the points of application of the stress a "uniform" solution is obtained sooner in the case of torsion than in that of either tension or pressure. S. H. B.

1287. *Tensions produced in the Interior of an Indefinite Solid by Two Equal and Opposite Forces.* **Mesnager.** (Comptes Rendus, 133. pp. 1286–1287, Dec. 30, 1901.)—According to the author Flamant proved that in two dimensions a pressure p applied normally to a solid bounded by a line, and maintained at infinity, gives in the interior Lamé's ellipses reduced to a line equal to $-2p \cos \alpha/\pi r$ in the line joining the point of application of p to the point considered. The author superposes another solid coinciding with the former, but with an applied force $f = -p$. He then says that the isostatic lines in the solid so constituted are concentric circles about the point of

application of the pressure, and the tensions are constant along circles passing through the point of application and centred in the normal. He then finds, by a geometrical construction, the resultant effect at a point in the interior. If at two points A and B equal and opposite forces are applied, the isostatic surfaces are circles of the stereographic projection constructed with A and B as poles. On the circle whose diameter is A B the two principal resultant forces, defined by the author, are equal, of the same sign, and constant.

S. H. B.

1288. *Dynamical Equations of Anolonomous Systems.* **G. A. Maggi.** (Accad. Lincei, Atti, 10. pp. 287–292, Dec. 15, 1901.)—The discussion in this paper is of a material system subject to connections which may vary with the time, and of the proper form of the differential equations applicable to such a case. They were deduced from Hamilton's theorem by Kirchhoff in his Mechanik in a general form. Volterra, in the Atti delle R Accademia delle Scienze di Torino, obtained a set of equations satisfying the conditions in terms of the "characteristic" functions of the motion, and equal in number to the degrees of freedom of the system. Finally, Appell (in vol. 129 of Comptes Rendus, "On Equations Analogous to those of Lagrange," and "On a General Form of the Equations of Dynamics," Crelle's Journal, 1900) has given another solution, using the same method of the characteristic functions. The present writer treats the subject in a purely theoretical manner. He starts from Hamilton's $\int_t^{t'} (\partial T + \Pi)\partial t = 0$, and by the aid of Lagrange, shows how to deduce both Volterra's and Appell's forms of the general equations. In conclusion he discusses an objection raised by Appell to the general method. Appell had shown that *holonomy* is a necessary and sufficient condition for the virtual and effective motions of a system being subject to the same connections.

S. H. B.

1289. *Capillarity Constants of Crystal Faces.* **H. Hilton.** (Phil. Mag. 3. pp. 144–148, Jan., 1902.)—The author discusses a theorem of G. Wulff given in Zeitschrift f. Kryst u. Min., vol. 34, 520. According to this theory, if k_1, k_2, k_3, &c., be the capillarity constants on the different faces, n_1, n_2, n_3, &c., the normals which define the faces, the surface energy is—

$$E = p\,(k_1 n_1^2 + k_2 n_2^2 + \&c.),$$

where p is a constant, and the volume is—

$$V = q\,(n_1^3 + n_2^3 + \&c.)$$

Now E must be minimum, given V. This requires that—

$$dE = 2p\,(k_1 n_1\,dn_1 + k_2 n_2\,dn_2 + \&c.) = 0$$

$$dV = 3q\,(n_1^2\,dn_1 + n_2^2\,dn_2 + \&c.) = 0,$$

which (says Wulff) cannot be unless $k_1 : k_2 : k_3 \ldots = n_1 : n_2 : n_3 \ldots$ The writer says the proof is faulty, on the ground, firstly, that the expressions for E and V should be $E = k_1 p_1 n_1^2 + k_2 p_2 n_2^2 + \&c.$,

$$V = \tfrac{1}{3}\,(p_1 n_1^3 + p_2 n_2^3 + \&c.),$$

where p_1, p_2, &c., are constants. This, however, does not affect the argument, because Wulff has assumed the ratios $n_1 : n_2 : n_3$, &c., constant. Secondly, because Wulff tacitly assumes dn_1, dn_2, &c., to be independent. The proof

however, as the author shows, can be made good. It is proved, namely, that a point 0_1 exists for which if n_1 n_2 be the perpendiculars on the faces, $n_1 : n_2 : n_3 \ldots = k_1 : k_2 : k_3 \ldots$ and the theorem is applied to a particular case. S. H. B.

1290. *Hecker's Determination of Gravitation on the Atlantic Ocean.* **F. R. Helmert.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 8. pp. 126–128, Feb. 13, 1902.)—Mohn having shown that mercury barometers can be corrected for gravitation by the aid of hypsometers, the author sent Hecker, in summer, 1901, on a Hamburg steamer from Lissabon to Bahia with four barometers and six hypsometers. The different instruments agreed well with one another. Gravitation seems to be normal over the deep water of the Atlantic, in accordance with Pratt's theory of isostatic stratification of the earth's crust. The Bay of Biscay appears to form a deep valley over which gravitation is less than normal. H. B.

1291. *Propagation of Earthquake Motion.* **G. Grablovitz.** (Accad. Lincei, Atti, 11. pp. 177–185, Feb. 16, 1902.)—The author distinguishes three distinct phases in earthquake movements, viz. : (1) Rapid, probably longitudinal, oscillations'; (2) slower movements of somewhat difficult interpretation ; (3) much slower, probably transversal oscillations. These oscillations reach the observing instruments, in general, at different times, so that one can estimate from the interval of time between the first phase and the third the distance of the centre of disturbance. The author in this way, basing his calculations on Cancani's (fixed) velocities for the first and third phases, formerly obtained the coefficient, 300 km., for every minute's interval between the first and third phases. He now finds, from an examination of recent data, that the first phase propagates itself with varying velocity, so that the above coefficient varies from 329 at 40° distance to 260 at a distance of 120°. These considerations apply only to propagations to long distances ; the author emphasises the futility, with the present chronometrically inexact seismograms, of attempting to generalise the rates of propagation over very limited areas. D. H. J.

1292. *The Hungarian Salt Lakes as Natural Heat Accumulators.* **A. v. Kalecsinsky.** (Ann. d. Physik, 7. 2. pp. 408–416, Feb., 1902. Paper presented to the Hungarian Academy of Science, Oct. 21, 1901.)—North-east of Szováta, in the Comitat of Maros-Torda, lies the Sóhát or salt ridge, with salt springs, salt rocks up to 50 m. high, little rivulets, and a number of salt lakes. In three of these, notably in the Medve Lake (average depth 10 m.), the surface temperature is approximately that of the atmosphere, but at a depth of 1·32 m. the temperature may vary between 69° C. in September and 26° C. in April; with greater depths the temperature decreases again. There are no hot springs nor any chemical processes to account for the high temperature, nor did artificial ponds, made by the author in the clay soil and filled with fresh or with salt water, show any peculiarity. But when a layer of fresh water was spread on the salt water, the higher temperatures were observed in the denser salt water. The density of the Medve water is 1·038 (3 per cent. of NaCl) at a depth of 0·1 m., and reaches 1·183 (24 per cent.) at 1·5 m. and 1·196 (25 per cent.) at 5 m. According to P. Lenard, insulation completely explains the phenomenon, and salt lakes can, therefore, be turned into heat accumulators ; the slightly saline surface layer of water should not be more than 2 m. in thickness. H. B.

1293. *The Dynamics of Cyclones.* **J. Aitken.** (Roy. Soc. Edinburgh, Trans. 40. 1. pp. 131–156, 1901.)—Vortices will not occur either in air or water unless, in addition to the low pressure, there is some initial circular motion. Otherwise, the air, or water, will flow towards the low-pressure centre radially. This is illustrated by the familiar phenomenon accompanying the emptying of a basin of water by opening an orifice at its lowest point. A noteworthy feature in water vortexes so formed is a great increase in the velocity of the water as it approaches the centre of the movement. The author clearly illustrates this by means of two suspended balls capable of rotating about a common centre, and kept, by means of a cord, at a fixed distance, which can be decreased by shortening the latter. If this is done while the balls are revolving around the common centre, there is no resulting increase of energy, as the natural force is perpendicular to the direction of movement. When, however, the balls are moving in a spiral path, there is but one component of the radial force acting in the direction of the motion, which increases the velocity. The resistance offered, in the case of a cyclone, by the spirally moving air, enables the latter to develope more energy than if the air moved inwards radially, as the retardation causes a fall of pressure, and the energy of the cyclone is increased.

In an experiment in which columns of fume created by hydrochloric and ammonia rising from a table covered with a glass plate are made to ascend into a heated tube, while a rotating motion is caused by an artificial air-current passing over one portion of the area while the other is protected by a screen, the author demonstrates, among other facts, that the air near the surface of the area moves much more radially than that which is higher, and that the former is drawn into the very core of the cyclone, while the higher air forms the envelope. He then demonstrates by means of water vortexes that the tangential force not only is the cause of the rotatory movement, but that the whole low-pressure area moves in the direction of the greatest tangential force. He expresses the opinion that attention has been too much contemplated in the cyclonic area to the neglect of the equally important anti-cyclonic area. If an anti-cyclone is blowing outside a heated area, some hundreds of miles in diameter, from which columns of air are rising vertically, the upper air descending would, upon reaching the surface of the ground, spread radially over the paths were it not changed into spiral paths owing to the earth's rotation. As the air near the surface of the ground moves more radially than the upper air, the higher currents cross the lower at a greater or lesser angle, and check its rising even if lighter than the upper strata. Thus the anti-cyclone prevents the formation of local cyclones, and drives all the moist hot air to the circumference, keeping it near the ground. Hence the air in front is hotter and moister than behind. If now the hot air begins to form a cyclone outside of the anti-cyclone it has a supply of hot air collected for it by the anti-cyclone, and owes to the latter also the tangential force required for its spiral circulation. The cyclone, however, with strong winds blowing tangentially on one side, must move in the direction of these winds, and only by so doing can renew its supply of moist, hot air. The Synoptic Charts issued by the Meteorological Office support the author's theory that the tangential winds are the principal cause of the movement of the cyclone as a whole, and that the centre of depression moves in the direction of, and nearly parallel to, these winds. The part played by the anti-cyclone in the vertical circulation of our atmosphere has, according to the author, received too little attention. The effect of cold is as important in the movement of winds as the sun's heat. In summer the latter gives rise to cyclonic conditions in the

air over continental areas, while in winter the earth's radiation gives rise to anti-cyclonic conditions, and is as true a cause of vertical circulation as the heating of it, though, perhaps, to a smaller extent. The lower air sent forward by the anti-cyclone is swept off its circumference by the cyclone and drawn into the cyclone, curving round the front of it, and in its passage draws with it the hot, moist air in front of the cyclone area. The author in conclusion states his reason for preferring this dynamical theory to the ordinary convectional theory. G. G.

1294. *Hail Cannonades.* **J. R. Plumandon.** (Revue Scientif. 17. pp. 174–178, Feb. 8, 1902. Report presented at the Third International Hail Defence Congress, Lyon, Nov. 15 and 17, 1901.)—Hailstorms have diminished in some districts, but there was also a decided periodical decrease in their number in the years 1886 to 1892. People speak of the conversion of hail into snow by the cannonades, though snowfalls are not in general rare with thunderstorms, and were previously known in these localities. Hail showers are, moreover, so peculiarly local that the best cases of hail stoppage and prevention are doubtful. The author advocates careful official meteorological observations and systematic distribution of the guns. At Denicée 52 guns are distributed, 500 m. apart, over a rectangular area; at St. Gengoux-le-National they are arranged along the hailstorm line; in the Beaujolais district 340 guns are stationed on 18 fields, covering 10,000 hectares. He would place the guns in long bands, normal to the narrow hailstorm bands. H. B.

1295. *Cosmogony.* **S. Arrhenius.** (Archives Néerlandaises, 6. pp. 862–873, 1901.)—In this paper the author endeavours to show that, without going beyond known natural laws, we may legitimately infer that the universe has continued without materially changed conditions for an indefinitely long time, and that it will so continue for an indefinitely long period in the future. Following Newcombe's modification of an argument by Lane as to the conditions of a mass of gas contracting under the influence of its own gravitation, the ordinary gaseous laws being supposed to hold, he shows that, for the ordinary monatomic and diatomic gases forming the bulk of the gaseous matter known to be in existence, such a mass will, before it has contracted to one-eighth of its volume, with a corresponding increase of its pressure in the ratio of 16 : 1, and a consequent doubling of its initial temperature, begin to lose heat by radiation, while continuing to rise in temperature. If the pressure increases more rapidly than this, a second stage will be reached in which the mass will be cooled by contraction; and with such gases as hydrogen and nitrogen, Amagat's investigations show that this will occur at pressures of more than 250 to 300 atmospheres at about 17° C. The densities of the nebulæ are much less than this, so that if they lose heat by radiation, their temperatures will increase more rapidly, and therefore, conversely, the communication of heat from outside will cause cooling accompanied by expansion. This expansion would continue indefinitely if it were not for bodies, such as comets and meteorites, which are aggregated by their mutual gravitation into solid nuclei around which the gases become condensed, so forming new stars, which take up the energy from the older ones as they cool down. When these latter begin to form a solid crust, the loss of energy will immediately fall to an insignificant percentage of its immediately preceding value. This third stage will therefore continue for an indefinitely long time compared with the other two, and it may therefore be inferred that the number of dark bodies in space is very much greater than that of luminous ones. Bodies in

the second and third stages will contain in their interior, owing to the high temperature, only substances which are extremely stable, viz., those having great potential energy, and they will be greatly compressed. Collisions will therefore give rise to explosive outbursts of gases, and it is shown that these would give rise to spiral nebulæ, and also that the new stars forming their nuclei would show the displacement of the dark lines towards the violet end of the spectrum, and of the bright lines towards the red end, which is characteristic of those observed.

The author points out that there will be practically no dissipation of gravitational energy during expansion, and none through ordinary chemical dissociation. Some dissipation is necessary, however, to prevent the indefinite increase of entropy. This the author finds in photochemical processes forming the inverse of those which occur on the surface of the earth for example. Under these conditions, the series of changes may go on without intermission, but in order that the entropy may remain constant, the average period of the cyclical changes must ever increase, so that the quantity of nebulous material in existence must continually become greater, while that of the stars must correspondingly decrease. G. W. DE T.

1296. *Solar Theory.* **J. Halm.** (Nature, 65. pp. 351–354, Feb. 13, 1902.)—The author commences by inquiring what may be the influence on the solar atmosphere of a change in opacity or absorbing power of that atmosphere itself. Langley calculated that an increase in the absorption of the sun's atmosphere of as little as 20 per cent. would lower the mean surface temperature of our earth by at least 100° F., so that the effect of changes would be enormously greater at the surface of the sun itself. Coming next to a consideration of Helmholtz's theory, in which the heat generated by the gravitational contraction more or less compensates for the heat lost by radiation, he assumes that the sun has passed the critical stage where these two quantities are equal, and that consequently it is on the down grade with respect to temperature. Under these conditions the progressive cooling of the star would lead to the formation of an absorbing envelope above its photosphere, by which the disproportion between the generation and loss of energy would be reduced, but the gradual increase of the absorbing stratum would continue. At some time the energy reflected back to the nucleus from the layers of this stratum would, together with the contractile energy, again balance the radiation expenditure. The importance of this is seen when it is considered that when such a stage is arrived at the layer in question will afterwards become relatively overheated, and the continuance of such will ultimately give rise to such pressure that the equilibrium of the system is broken down, and a solar disturbance produced which may reach the surface of the photosphere. On developing the analytical discussion of these conditions a result is found which possibly corresponds with the known periodicity of solar phenomena. One of the most important of these is the peculiar shift of the maxima at different epochs during different solar cycles, this being accounted for by the reaction of convection disturbances on the main period of disturbance. C. P. B.

1297. *Hertzian Waves Emanating from the Sun.* **H. Deslandres** and **Décombe.** (Comptes Rendus, 134. pp. 527–530, March 3, 1902.)—This is a short discussion of the probability of Hertzian oscillations being emitted from the sun. The reason why all attempts to recognise such have hitherto failed

may be partly due to the strong absorption by our atmosphere, and also to the proper receiving apparatus not being used. The author suggests a receiving wire parallel to the earth's axis, and provided with a triple terminal having components mutually at right angles, so as to arrest vibrations polarised in any plane. C. P. B.

1298. *The Brightness of a Star and the Moment of Perception.* **H. G. van de Sande Bakhuyzen.** (Konink. Akad. Wetensch. Amsterdam, Versl. 10. pp. 631–634, Feb. 22, 1902.)—In a previous article [see Abstract No. 817 (1902)] the author considered the influence of the brightness of a star on the time of perception of its appearance, and the bearing of those results on the variation of personal equation in transit observations. He now records similar experiments on the sudden disappearance of luminous points of varying brightness, the degree of brightness being reduced to magnitudes of stars by means of a simple device analogous to Glan's spectrophotometer.

The following table shows the relation between brightness and time of perception on appearing and disappearing :—

Magnitude.	Personal Error on Appearing.	Personal Error on Disappearing.
5·7	0·275secs.	0·314secs.
7·4	0·316	0·329
8·6	0·413	0·387
9·5	0·530	0·489

The differences of the personal error for different brightnesses are independent of the form of apparatus used. The influence of those variations of personal equation upon astronomical determinations of position and observations of covering of stars is pointed out. A. G.

1299. *Nebulosity about Nova Persei.* **G. W. Ritchey.** (Astrophys. Journ. 15. pp. 129–131, March, 1902.)—Further photographs have been obtained with the 24 in. Yerkes reflector, which show that the changes in form of the nebulous surroundings of the Nova still continue. Drawings are reproduced from five of the best negatives. The principal ring of nebulosity first detected has continued to fade rapidly, only two of the chief condensations in it being perceptible. The strong condensation close to the Nova has, however, not apparently changed in brightness since November 9, 1901, but its form shows slight expansion towards the south.

Other portions show rapid radial movement outward from the Nova. Of course the changes may not be due to an actual movement of matter, but to the successive changes of illumination of various portions of a stationary nebula. [See also Abstracts Nos. 447 and 448 (1902).] C. P. B.

1300. *Movements and Changes in Nebulosity round Nova Persei.* **C. D. Perrine.** (Astrophys. Journ. 15. pp. 136–141, March, 1902.)—The paper contains list of photographs showing the nebulosity and descriptions of the changes found on measurement. Originally the principal ring of nebulosity was not circular, but in the form of an irregular oval considerably flattened on the south-west side. The longer axis was in position 115°. Inside this was a smaller and fainter nebulous structure, almost perfectly elliptical in form. The major axis of this lay in position angle 60°, and was 2′·5 in length. The successive changes shown in the photographs are described in detail.

C. P. B.

1301. *Chemical Origin of the Spectrum Lines in Nova Persei.* **J. N. Lockyer.** (Roy. Soc., Proc. 69. pp. 354–360, March 7, 1902.)—In strong contrast with the published origins of other observers, the first stages of the Nova spectrum are here considered as chromospheric, and collateral evidence is adduced to show the coincidence of many of the principal groups with well-marked lines in the spectrum of α Cygni, which recent work at Kensington shows to be due to the "enhanced" type of metallic spectra. Moreover, in the star η Argus we have a constant spectrum of very similar constitution to the temporary one exhibited by the Nova Persei.

Tables of the wave-lengths and probable origins of the lines measured from photographs are given, with comparison values given by Campbell and Vogel. The substances indicated as present are Ca, Fe, Ni, Ti, Sr, Si, Sc, Cr, and Mg, all in the *proto-* or enhanced form. [See also Abstracts Nos. 20 and 447 (1902).] C. P. B.

1302. *The Flash Spectrum.* **S. A. Mitchell.** (Astrophys. Journ. 15. pp. 97–121, March, 1902.)—The paper contains the results of photographic observations of the total solar eclipse of May 18, 1901, taken in Sumatra. Two instruments were set up—a telescope used to photograph the corona and a spectroscope consisting of a flat Rowland grating and quartz lenses. With this instrument eight films were exposed, and of these two for the flash spectrum. The clouds seriously interfered with the observations, but the negative of the second flash was good though not in perfect focus. A table is given of the wave-lengths obtained from this film between the limits $\lambda = 4924$ to $\lambda = 3835$. The author divides the flash lines into three groups: (1) Lines strong in flash and in the solar spectrum; (2) lines strong in flash and weak in the solar spectrum; (3) lines weak in flash and strong in the solar spectrum. This grouping of lines is identical with that adopted by Evershed from his observations on the Indian eclipse. [See Abstract No. 294 (1902).] By measuring the angular extent of the bright arcs an approximate estimate of the depths of the layers of the different elements was formed, and they vary from 8″ for hydrogen to 0·5″ for iron. The author disagrees with Lockyer's theory (see preceding Abstract) that enhanced lines are especially evident in the flash, because an enhanced line with no solar counterpart is not to be found in the flash, and, further, all the enhanced lines which do appear in the flash are strongly in evidence in the solar spectrum. E. C. C. B.

1303. *Velocities of Gas Nebulæ.* **J. Hartmann.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 12. pp. 237–244, Feb. 27, 1902.)—The paper describes spectrographic measurements carried out on the nebulæ G.C. 4390, 4373, and N.G.C. 7027. In the case of the first nebula the hydrogen lines $H\beta$ and $H\gamma$ were measured, and from the values obtained the velocity of the nebula was calculated. Corrections were then applied to the wave-lengths of the two nebula lines N_1 and N_2, and the final numbers are $\lambda = 5007{\cdot}04$ and $4959{\cdot}17$. Keeler's measurements of the wave-lengths of the same lines in the Orion nebula were $5007{\cdot}05 \pm 0{\cdot}03$ and $4959{\cdot}02 \pm 0{\cdot}04$. The difference between the two determinations of the more refrangible line the author considers is due to Keeler's having used a wrong value for the wave-length of one of the comparison lines. This line, one of the iron spectrum, is in reality a double, and Keeler used as the wave-length the mean of those of the two components. The author, however, does not agree with this on account of the difference in intensity of the two components. If a correction be applied to Keeler's

value it becomes 4,959·17. The measurements of velocity in the line of sight for the three nebulæ are as follows :—

G.C. 4390 — 10·5 km. per sec.
G.C. 4373 — 65·8 „ „
N.G.C. 7027 + 4·9 „ „

A slight difference in velocity was noticed between the edge and centre of the nebulæ. E. C. C. B.

1304. *Errors in Wave-Length Determinations.* **H. M. Reese.** (Astrophys. Journ. 15. pp. 142–147, March, 1902.)—It has been found that in measuring spectrograms for the determination of velocity in the line of sight, a systematic difference is found which appears to depend on the orientation of the length of the spectrum, violet to right end or left. Tables of experimental measures are given to show the degree of personal error introduced in this way, which has to be eliminated by duplicate reduction with plate in direct and reversed positions. C. P. B.

REFERENCES.

1305. *Electrical Detection of Distant Storms.* **J. J. Landerer.** (Comptes Rendus, 134. pp. 279–280, Feb. 3, 1902.)—An account is given of effects observed with an earthed overhead wire, 288 m. in length, with a galvanometer or telephone. W. R. C.

1306. *Conditions for Accurate Astronomical Photography.* **Loewy.** (Comptes Rendus, 134. pp. 381–387, Feb. 17, 1902.)—The paper contains a survey of the practical precautions necessary for the accurate determination of astronomical positions by photography, and also formulæ for reduction by allowing for the chief sources of error. C. P. B.

1307. *Theory of Capillarity.* **G. Bakker.** (Journ. de Physique, 1. pp. 105–115, Feb., 1902.)—A paper on the same lines as that referred to in Abstract No. 1475 (1901).

LIGHT.

1308. *Zonal Aberration of Lenses.* **S. P. Thompson.** (Archives Néerlandaises, 6. pp. 747–757, 1901.)—Let parallel rays fall on a (thick) lens, and, after passing through it, strike the axis at points $F_1F_2F_3$, &c. Then the points F_1F_3, &c., are not coincident with the point F_0 corresponding to the limiting position of paraxial rays, this want of coincidence being the "central" aberration, the ordinary spherical aberration of text-books. Again, if the paths of the rays before entering and after emerging from the lens be produced to meet at points $D_1D_2D_3$, &c., these points will lie on a surface, which is the principal surface, the point where it cuts the axis being identical with Gauss' principal point. The focal lengths D_1F_1, D_2F_2, &c., are not equal, this want of equality being the cause of the "zonal aberration." No simple lens can be free from both zonal and central aberration, the conditions for the two corrections being incompatible. The form of the principal surface will depend on the curvature of the lens faces; there will also be in every lens two such surfaces, one for a parallel beam in either direction. It is obvious that Gauss' assumption, that in every lens each principal surface is always a plane, is very far remote from actual facts. The author describes experiments made by placing a plano-convex lens obliquely in front of an arc light (with or without a condenser), the image thrown on a screen being balloon-shaped. By attaching a zone plate to the flat surface of the lens and moving the screen, the effects due to the various zones could be studied. The results are illustrated. Further, owing to the pencil after passing through the lens being no longer homocentric, extraordinary shadow phenomena appear on placing objects in the path of the beam. The shadow of a straight rod may be a ring, cross, figure 8, or triangle. A. E.

1309. *Lecture Illustration of Spherical Aberration.* **F. F. Martens.** (Deutsch. Phys. Gesell., Verh. 4. 4. pp. 41–42, Feb. 21, 1902.)—The effects may be shown by means of an ordinary projection lantern with a condenser consisting only of two simple lenses. Owing to spherical aberration, the image of the arc light formed by the condenser will not be sharp, the axial rays coming to a focus at a point further from the condenser than the marginal rays. On a screen placed at some metres' distance a large circular patch of light will be thrown, whose central portion is illuminated by axial rays, and outer portion by marginal rays. If a small disc, 8 mm. in diameter, be placed at the focus of the paraxial rays, a dark spot will appear on the screen, and as the disc is gradually moved along the axis towards the condenser the spot developes into a dark ring, which increases in diameter, until it reaches the edge of the patch when the disc is at the focus of the marginal rays. The disc may be attached to an optical bench. With a triple condenser the aberration is generally too small, but may be increased by turning the lens next the light back to front. A. E.

1310. *Fresnel's Interference Bands Produced by a Right-Angled Prism.* **F. F. Martens.** (Deutsch. Phys. Gesell., Verh. 4. 4. pp. 43–44, Feb. 21, 1902.)—The method affords a means of measuring the angle of an approximately right-angled prism. Rays from a slit are allowed to fall nearly

normally on the hypothenuse, and after two internal reflections again emerge nearly normally from the hypotenuse. If $90° - \alpha$ be the angle of the prism, the interval b between two dark bands is given by $b = \lambda/4an \,.\, (1 + l/L)$; l, L being the distances from the prism of the observer and of the slit. The bands may conveniently be observed by holding a small magnifier near the slit, so that $l = L$. The number will increase and brightness diminish as the prism is moved farther away, while b will remain constant. The width of the slit should only be a fraction of b, and its length not more than 1 cm. The angle α may also be measured in the following way: A telescope, with illuminated cross-wires in the eyepiece, is pointed directly at the hypotenuse. Two images of the cross-wires are formed by reflection, whose angular distance will be $4an$V, V denoting the magnifying power of the telescope. This angle may be measured by utilising the circle and telescope of a small spectrometer reading to 1′. The small telescope, placed with the centre of the spectrometer under the eyepiece of the first telescope, is pointed at each of the two images in turn, and the angle β between the two positions is read off on the circle. We have then $\alpha = \beta/4n$V. A. E.

1311. *Optical Constants of Biaxial Crystals by the Refractometer.* **A. Cornu.** (Journ. de Physique, 1. pp. 136–147, March, 1902. Paper read before the Société Française de Physique, Dec. 6, 1901.)—This is a continuation of the work referred to in Abstract No. 1868 (1901). The formulæ there referred to are here worked out, and their employment for the determination of the optical constants is illustrated. The additional matter is entirely analytical. J. W. P.

1312. *Index of Refraction of Red-hot Platinum.* **P. Zeeman.** (Archives Néerlandaises, 4. pp. 314–317, 1901.)—The optical constants of platinum up to 200° were determined by the Babinet's compensator, and the observations were taken to decide questions in dispute between Kundt and Kolaček on the one hand and Sissingh and Drude on the other. Kundt found that the index of refraction of platinum increases by about 27 per cent. for a temperature rise of 100°, while Drude found for platinum, silver, and gold only very small variations. The author finds very small effects. For 800° rise the change of the index is not comparable with that found by Kundt for only 90°. Details of the instrument used are given. Its precision was less than that of the apparatus used by Kundt, but the above contradiction was clearly within the reliable range. J. W. P.

1313. *Half-tone Trichromatic Printing Process.* **F. E. Ives.** (Frank. Inst., Journ. 153. pp. 43–49, Jan., 1902.)—The article describes briefly the process of making three plates by a triple camera devised by the author. The three negatives are taken at one exposure on a single plate, and the subsequent operations are single instead of triple. In this way the number of operations is reduced from fifteen to five, and the printing plates harmonise better, as differences in exposure or development are avoided. Re-etching of the plates is consequently reduced to a minimum, and is frequently not required. A specimen colour-plate is appended. G. H. B.

1314. *Colour-photography.* **A. Hesekiel.** (Phys. Zeitschr. 3. pp. 194–195, Feb. 1, 1902. Paper read before the 73rd Naturforscherversammlung at Hamburg, Sept. 24, 1901.)—The author describes the production of trans-

parencies for three-colour photography, and claims to have so simplified the process as to make it practicable for any photographer. Prints are taken on bichromated celluloid and dyed the proper colours. G. H. B.

1315. *Spectrophotometric Experiments on Skin.* **Camichel** and **Mandoul.** (Journ. de Physique, 1. pp. 101–105, Feb., 1902.)—The coefficient of absorption of the skin of the cervical region of the Guinea-fowl varies with λ^4. This skin is physically identical in its action with a layer of lampblack. It holds back the harmful radiations of greater refrangibility, and allows the less refrangible rays to pass into the organism. A. D.

1316. *The Absorption Spectrum of the Indophenols.* **Camichel** and **Bayrac.** (Journ. de Physique, 1. pp. 148–151, March, 1902. Paper read before the Société Française de Physique, April 12, 1901.)—The usual definition of an absorption band in a spectrum in reference to its extremities is inconvenient owing to variations due to changes in concentration, nature of light employed, and the length of absorbing layer. The definition of a band by a point corresponding to the maximum or minimum of absorption coefficient is free from the above disadvantages. The position of this point may readily be determined on Crova's spectrophotometer. The slit of this instrument is divided into two parts, one being illuminated by a beam of light of intensity I_1, which passes through two nicols, and the other by a beam of intensity I_2, which passes through the absorbing substances. The two spectra are equalised, when $I_1 \sin^2 \alpha = KI_2$ where $\frac{\pi}{2} - \alpha$ is the angle of the nicols and K a constant. In practice the following method is employed: The eyepiece of the telescope of the instrument is provided with shutters to limit the observed region. The extremity of a band is observed and the two spectra made of equal brightness; the angle α is then read and also the scale-reading of the telescope. The latter is then slowly moved towards the other side of the band until the two spectra again become equal. A second scale reading is thus obtained for the same value of α. Several pairs of points of equal brightness in the band are obtained in this way, each pair giving a different value of α. The scale readings are then plotted against $\sin^2 \alpha$, there being of course two for each value of $\sin^2 \alpha$. A curve is drawn through the points and a line is drawn through the means of all the pairs of scale readings. This line, usually straight, will cut the curve at the point of maximum absorption. The authors applied this method to the spectrum of the indophenols. Their solutions in alcohol, ether, and carbon bisulphide show a coefficient of absorption proportional to the concentration, and the position of the maximum of absorption in the yellow does not change with concentration. The following results were obtained: (*a*) Kundt's law regarding the influence of the solvent was not found to be applicable. (*b*) The ortho substitution in the original phenol caused a considerable shift of the absorption maximum towards the more refrangible rays in any solvent. (*c*) The meta substitution caused a slight shift sometimes to one side and sometimes to the other. The replacing of a tertiary nitrogen atom by a primary nitrogen atom causes a shift of the band to the more refrangible end of the spectrum in any solvent. E. C. C. B.

1317. *The Effect of Sodium on the Hydrocarbon Bands in the Spectrum of the Bunsen Flame.* **P. Lewis.** (Astrophys. Journ. 15 pp. 122 124, March, 1902.)—A photometric test of the statement made by Scheiner that the

introduction of sodium vapour into a Bunsen burner flame which is showing the hydrocarbon bands makes no difference in the brightness of the latter. Measurements made with a Glan spectrophotometer showed that, if the sodium vapour be actually introduced into the green cone of the flame, the bands are very distinctly diminished. This is important in connection with the theory of the electric origin of the luminosity of comets. E. C. C. B.

1318. *Radiant Induction.* **T. Tommasina.** (Archives des Sciences, 13. pp. 261–273, March, 1902. Paper read before the Physical and Natural History Society of Geneva, Jan. 9, 1902.)—This is a further contribution to the question of the reflection and nature of the radiations of radio-active bodies referred to in Abstract No. 1062 (1902). The discharging action of the radio-active substance is shown not only for air as the medium, but for paraffin and alcohol; and the phenomena, in the author's opinion, cannot be adequately explained by ionisation nor by emission of electrified particles. All the effects of the various radiations are to be traced to a radiation from the anode, and this radiation is of the undulatory type. Thus the flux from the anode arouses the kathode rays; these, on striking a metallic plate, or the glass walls of the tube, give rise to Röntgen rays; these again further secondary rays, and so on. All these radiations are alike complex. They contain parts deviable by the magnetic field, parts non-deviable, rays of various penetrating powers, and so on. Since the nature of the rays depends only on the wave-length, the variety is unlimited. Experiments are described on the same lines as those referred to in the above Abstract, showing that there are in the Becquerel radiation non-luminous rays which have the power of discharging electrified bodies and which undergo reflection. J. W. P.

1319 *Radio-activity.* **F. Henning.** (Ann. d. Physik, 7. 3. pp. 562–575, March, 1902. Communicated by the Physikalischen Institut in Halle. (Abstract).)—Induced radio-activity was imparted to various wires and metal plates, the method of procedure being the same as that adopted by Rutherford [see Abstract No. 2109 (1901)], in which the object acted upon was made the kathode, and placed together with oxide of thorium in a closed brass tube, the tube itself forming the anode. The activity produced in the material exposed to the action of the thorium for about a day was measured by its capacity of producing conductivity in air. One of the objects of the experiments was to find the connection between the intensity of activation and the area of surface of the metal wires and plates. It was found that after the potential difference was raised to a certain value the increase of activity thereby produced was very small, though at first the activity rose rapidly in intensity as the potential difference was increased. With high tensions also no uniform law connecting the intensity of activation and the area of surface can be discerned; the activity appears to be quite independent of the surface. With small potential differences, however, the intensity of activation clearly increases with the surface. A condition of equilibrium appears to establish itself in which the particles or corpuscles to which the emanation is due disappear as rapidly as new ones are produced. The particles may disappear through deposit on the object or on the walls of the tube, and sometimes also direct into the air. The behaviour of metal plates which were rendered active was quite similar to that of wires. In the course of the experiments the potential was raised to 300 volts. An account is also given of experiments on the capability of producing conductivity which is shown by radio-active barium chloride. J. J. S.

HEAT.

1320. *Simple Method of Determining the Temperature of Luminous Flames.* **F. Kurlbaum.** (Phys. Zeitschr. 3. pp. 187–188, Feb. 1, 1902.)—The optical pyrometer devised by Holborn and the author [see Abstract No. 2122 (1901)] is employed. An image of the given flame is formed at the place where the filament of a 4-volt glow-lamp is fixed, and the latter is heated by a current until, attaining the temperature of the flame, it ceases to be visible when viewed through red glass, the temperature being deduced from preliminary observations with a black body, brought to various known temperatures, in place of the flame. This method gives lower estimates of temperatures than Lummer and Pringsheim's (*e.g.*, 1,431°±9° C. for a candle instead of 1,582°±105°), and doubtless more accurate ones; but it can only be employed when the luminous carbon particles in the flame are not surrounded by gases that exert an uncontrollable absorption within the spectrum-range used. R. E. B.

1321. *Dilatation of Steel at High Temperatures.* **G. Charpy** and **L. Grenet.** (Comptes Rendus, 134. pp. 540–542, March 3, 1902.)—The authors have determined by the dilatometric method of Le Chatelier and Coupeau the coefficients of expansion of a number of annealed carbon and nickel steels at temperatures at which there is no transformation of the steel. The results are given in the following tables—they seem to show that iron and carbide of iron have appreciably the same coefficient of expansion :—

TABLE I.

Composition of Steels.					Mean Coefficients of Expansion from					
C	Mn	Si	P	S	15° to 200°	200° to 500°	500° to 650°			
0·03	0·01	0·03	0·013	0·023	11·8×10−6	14·3×10−6	17·0×10−6	24·5×10−6	Between 880° and 950°	
0·25	0·04	0·05	0·010	0·010	11·5	14·5	17·5	23·3	,, 800° and 950°	
0·64	0·12	0·14	0·009	0·010	12·1	14·1	16·5	23·3	,, 720° and 950°	
0·93	0·10	0·05	0·005	0·010	11·6	14·9	16·0	27·5	,, ,, ,,	
1·23	0·10	0·08	0·005	0·009	11·9	14·3	16·5	33·8	,, ,, ,,	
1·50	0·04	0·09	0·010	0·010	11·5	14·9	16·5	36·7	,, ,, ,,	
3·50	0·03	0·07	0·005	0·010	11·2	14·2	18·0	33·3	,, ,, ,,	

TABLE II.

Analysis.			Mean Coefficients of Expansion from				
Ni	C.	Mn.	15° to 100°	100° to 200°	200° to 400°	400° to 600°	600° to 900°
26·9	0·35	0·30	11·0×10−6	18·0×10−6	18·7×10−6	22·0×10−6	23·0×10−6
28·9	0·35	0·36	10·0	21·5	19·0	20·0	22·7
30·1	0·35	0·34	9·5	14·0	19·5	19·0	21·3
34·7	0·36	0·36	2·0	2·5	11·75	19·5	20·7
36·1	0·39	0·39	1·5	1·5	11·75	17·0	20·3
32·8	0·29	0·66	8·0	14·0	18·0	21·5	22·3
35·8	0·31	0·69	2·5	2·5	12·5	18·75	19·3
37·4	0·30	0·69	2·5	1·5	8·5	19·75	18·3
25·4	1·01	0·79	12·5	18·5	19·75	21·0	35·0
29·4	0·99	0·89	11·0	12·5	19·0	20·5	31·7
34·5	0·97	0·84	3·0	3·5	13·0	18·75	26·7

D. H. J.

1322. *Heat-conductivity of Copper.* **W. Schaufelberger.** (Ann. d. Physik, 7. 3. pp. 589–630, March, 1902.)—The stationary- and variable-temperature methods of determining conductivity seem to give discordant results: the author finds that this is in part due to the assumption generally made that the end of a heated bar acquires the temperature of the water with which it is

surrounded—which may lead to a 10 per cent. error. A uniform bar of very pure copper, 9·5 cm. long and 7·03 mm. in diameter, with copper discs, 4 mm. thick and 5 cm. in diameter, driven on to its ends, was placed axially into a glass tube, the discs serving to close the tube and to lead a 20-ampere current through the rod. Iron-constantan thermoelements were inserted into holes bored at the middle of the rod and 7·5 mm. from its ends. The whole was immersed in water at 18°, a constant stream of which was continuously driven against the two discs. From readings taken when the temperatures were stationary the conductivity was found to be 0·9480, and from renewed readings with falling temperatures after the current had been cut off, the value found was 0·9382. These numbers differ by only $\frac{1}{2}$ per cent. from their mean. A complete mathematical theory of the experiments is given, together with an investigation of the effect of the falling temperatures on the motion of the galvanometer needle. R. E. B.

1323. *Equilibrium of a Heavy Gas.* **F. M. Exner.** (Ann. d. Physik, 7. 3. pp. 683–686, March, 1902.)—The author considers the equilibrium of an ideal gas in a long, vertical, non-conducting tube of unit section, assuming, however, gravity to be uniform. If the characteristic is $p = \mathrm{R}T\rho$, where ρ denotes density, the whole entropy is $\int_0^\infty (\mathrm{B} + c \log \mathrm{T} - \mathrm{AR} \log \rho)\rho dh$, where A is the heat-equivalent of work, B a constant, and c the isometric specific heat, h denoting height: and this entropy must be a maximum, while the whole mass $\int_0^\infty \rho dh$, and the whole energy $\int_0^\infty (\mathrm{D} + c\mathrm{T} + \mathrm{A}gh)\rho dh$ [which the author gives wrongly as $\int_0^\infty (\mathrm{CT} + gh)\rho dh$, where C is the isopiestic specific heat] are constant, and $dp = -g\rho dh$. Application of the Calculus of Variations then gives—

$$(d/dh) \log \mathrm{T} + g/\mathrm{RT} = -(d/dh) \log \rho = \text{constant} = \nu ;$$

whence $\nu\mathrm{RT}/g - 1 = (\nu\mathrm{RT}_0/g - 1)\, e^{\nu h}$ and $\rho = \rho_0 e^{-\nu h}$, so that $p_0 \equiv \mathrm{M}g = \rho_0 g/\nu$, and thus $\nu = g/\mathrm{RT}_0$ and $\mathrm{T} = g/\nu\mathrm{R} = \mathrm{T}_0$, the subscripts referring to $h = 0$. Hence the temperature is the same throughout the column when it is in equilibrium. R. E. B.

1324. *Heat Conductivity of a Gas in Motion.* **L. Natanson.** (Acad. Sci. Cracovie, Bull. 3. pp. 137–146, March, 1902.)—According to his usual method the author takes $u + \xi$, $v + \eta$, $w + \zeta$ for component velocities of the "material points," or "molecules," of which the gas is assumed to consist. Here $u\ v\ w$ are introduced as the components of "*vitesse hydrodynamique*" of the "element of volume" in which the molecule whose component velocities are $u + \xi$, &c., is at the instant considered. It is necessary to assume here that an infinitely small space contains an infinite, or great, number of these molecules, and that consequently a molecule cannot have finite dimensions or occupy exclusively a finite part of space. For if it did, the "element of volume" must be finite, and $u\ v\ w$ would generally depend on the size of the element chosen, and so would be indeterminate. $\xi\ \eta\ \zeta$ are the velocities of the molecules in the element relative to their common centre of inertia, so that $\bar{\xi} = \bar{\eta} = \bar{\zeta} = 0$.

Q denotes any function of the velocities, $\bar{\mathrm{Q}}$ its mean value. And d/dt as

applied to any such function stands for $\partial/\partial t + u\partial/\partial x + v\partial/\partial y + w\partial/\partial z$. The fundamental equation of the theory is then—

$$\rho\frac{d\overline{Q}}{dt} + \frac{\partial}{\partial x}\left(\overline{\rho\xi Q}\right) + \frac{\partial}{\partial y}\left(\overline{\rho\eta Q}\right) + \frac{\partial}{\partial z}\left(\overline{\rho\zeta Q}\right)$$
$$= \rho\frac{\delta\overline{Q}}{\delta t} + \rho\left(X\frac{\partial\overline{Q}}{\partial u} + Y\frac{\partial\overline{Q}}{\partial v} + Z\frac{\partial\overline{Q}}{\partial w}\right),$$

in which ρ denotes density—but without a definition in the present paper—$\frac{\delta}{\delta t}$ denotes variation due to intermolecular action, and X Y Z are components of external force. The method followed consists in giving to Q different values as functions of the velocities. In the present paper they are successively—

$$Q = u + \xi,\ Q = (u+\xi)^2,\ Q = (u+\xi)(v+\eta),\ \&c.$$
$$Q = (u+\xi)\left\{(u+\xi)^2 + (v+\eta)^2 + (w+\zeta)^2\right\}.$$

In working out these formulæ, the function Ψ is employed, namely—

$$\Psi = \rho\overline{\xi^2}\frac{\partial u}{\partial x} + \rho\overline{\eta^2}\frac{\partial v}{\partial y} + \rho\overline{\zeta^2}\frac{\partial w}{\partial z}$$
$$+ \rho\overline{\xi\eta}\left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\right) + \&c.,$$

or for small disturbances—

$$\Psi = \frac{\rho}{3}\left(\overline{\xi^2} + \overline{\eta^2} + \overline{\zeta^2}\right)\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}\right),$$

and this again assumes the form $-\frac{2}{3}c\theta\frac{d\rho}{dt}$, where c is the specific heat at constant volume. Hence, approximately,

$$c\rho\frac{d\theta}{dt} + \Psi = c\rho\theta\frac{d}{dt}\log\frac{\theta}{\rho^{\frac{2}{3}}}$$

This is compared with the known law of Laplace and Poisson for the "*détente*" of a gas. The author obtains in a more general form the relations between "flux" and "stimulant" given in his former memoir. He considers also the case in which the gas in which heat is propagated has uniform motion of dilatation or contraction denoted by—

$$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y} = \frac{\partial w}{\partial z} = \frac{1}{3}\theta$$

If, he says, an observer could distinguish the effect of pure conduction from this motion, the coefficient, K, of conduction of heat would become $K' = K\left(1 - \frac{7}{8}\theta T\right)$. Here T is defined by the equation—

$$\frac{\delta}{\delta t}\overline{\xi(\xi^2 + \eta^2 + \zeta^2)} = -\frac{\overline{\xi(\xi^2 + \eta^2 + \zeta^2)}}{T}$$

S. H. B.

1325. *The Boiling-point of Selenium and other Pyrometric Constants.* **D. Berthelot.** (Comptes Rendus, 134. pp. 705–708, March 24, 1902.)—By the interference method previously applied to the determination of the boiling-points of cadmium and zinc [see Abstract No. 2183 (1900)] the author has now determined that of selenium to be $690° + (H - 760)/10$, H being the barometric pressure in millimetres of mercury. Equality of temperature between the gaseous column and the selenium bath was tested by means of a platinum-iridium thermo-couple. The author considers the estimation as probably accurate to $\pm 2°$.

W. E. T.

1326. *Specific Heat of Bodies at Absolute Zero.* **Ponsot.** (Comptes Rendus, 134. pp. 703–705, March 24, 1902.)—Discussing a gaseous homogeneous mixture of bodies in chemical equilibrium, the author deduces the general law that at absolute zero two systems of solid bodies comprising the same elements have the same specific heat, and as a particular case that the specific heat of a compound in the solid state is equal to the sum of the specific heats of its separate elements in the solid state. It further is shown that the specific heat of a solid body and that of its saturated vapour both tend towards the value zero for absolute zero of temperature. W. E. T.

1327. *Thermic Equivalent of Dissociation and of Vaporisation and Heat of Solidification of Ammonia.* **de Forcrand.** (Comptes Rendus, 134. pp. 708–711, March 24, 1902.)—From the general relation [see Abstract No. 2419 (1901)], $(L + S)/T = Q/T' = (L + S + q)/T' = q/\theta = K = 30$, it follows that, when q becomes equal to 1 Cal., the mean value of θ is 33°·33. This number, the thermic equivalent of dissociation, expresses that, if a dissociable compound has a tension of 760 mm. at a temperature n degrees above the temperature of ebullition of the gaseous molecule, the total heat of combination exceeds by $n/33{\cdot}33$ the heat of solidification of this molecule. It also follows that the same number is the thermic equivalent of vaporisation and that a dissociable body having a tension of 760 mm. at n degrees absolute temperature will have a total heat of formation of $n/33{\cdot}33$. A study of the ammoniacal metallic chlorides leads to the mean value 31°·10 for their thermic equivalent of dissociation, in close agreement with the value 31·2, deduced from the mean value 32, of the ratio Q/T for this series. It follows that the heat of solidification of NH_3 gas will be + 7·695 Cal.; and in general the heat of solidification of a gaseous molecule can be determined when the dissociation and heat of formation of a certain number of its dissociable combinations are known, or the temperature may be determined at which a compound, for which Q is known, will have a tension of 760 mm. W. E. T.

1328. *Latent Heat of Fusion of Solid Ammonia.* **G. Massol.** (Comptes Rendus, 134. pp. 653–655, March 17, 1902.)—By dissolving in water (at 10°) liquid ammonia at −75°, and solid ammonia at a temperature as near as possible to −75°, the author has experimentally determined their heats of solution as respectively + 1·77 Cal. and − 0·068 Cal. Subject to the small error arising from the impossibility of taking the substance in both states at exactly the same temperature, it follows that the molecular latent heat of fusion of solid ammonia is − 1·838, very nearly equal to that of water.

W. E. T.

1329. *Heat of Solution of Cadmium Sulphate.* **H. B. Holsboer.** (Zeitschr. Phys. Chem. 39. pp. 691–710, March 18, 1902. Abstract from an Inaugural Dissertation, Dec., 1900.)—As the number of water molecules present with 1 $CdSO_4$ molecule increased from 14 to 500, the specific heat of the solution, determined by Berthelot's method, was found to increase from 0·610 to 0·972, the increase becoming less rapid as the solution became more dilute. The specific heat of the solid hydrate, $CdSO_4 . 8/3\ H_2O$ was found to be 0·225. The heat of solution at 15° of this hydrate with 404 water molecules, and the heat evolved on diluting solutions of various concentrations were next determined, and thence the heats of solution at 15° of the solid hydrate in various quantities of water were calculated. The heats of solution at 5° and 25° were deduced from this, and the specific heats, as determined above, and the

corresponding curves drawn. By Roozeboom's construction (Verslag. Kon. Acad. van Wetensch. 28 Feb., 1885, and Rec. 4, 135, and Rec. 8, 123. 1889), or van Deventer's calculation method (Zeitschr. Phys. Chem. 5, 555, 1890, and 9, 53, 1892), the theoretical heat of solution in the saturated solution was determined. At lower temperatures this was found to be positive, vanishing about 15° and being negative for higher temperatures, thus in harmony with the minimum of solubility of the hydrate found at 15° by Kohnstamm and Cohen. [See Abstract No. 1059 (1898).] W. E. T.

1330. *Effect of Heat on the Texture of Silica Jelly.* **J. M. van Bemmelen.** (Archives Néerlandaises, 6. pp. 607–624, 1901.)—The author had previously shown that the jelly really consisted of a kind of tissue, which had been shown under the microscope by Bütschli and Hardy to exist as an open network, or as a mass of polygonal cells 1·4 to 1·5 μ in diameter, with walls about 0·3 μ thick. The large quantity of water absorbed and enclosed is not in chemical combination, and can be replaced by other liquids. When slowly dried at ordinary temperatures, the jelly at a certain point, called by the author the "change-point" (umschlagspunkte), loses its transparency through air entering the cells, but becomes clear again when this is displaced by a miscible liquid. The absorbed air is found to be condensed to a pressure of 1 atmosphere. When the jelly is dried over H_2SO_4 till its vapour tension is reduced to zero, 0·3 to 0·1 molecule of water to 1 of SiO_2 is left. By exposure to aqueous vapour the cell cavities gradually refill with water, while the air is expelled, the volume of the jelly remaining almost unchanged, until finally as much water is absorbed as was present at the point of change. The phenomena can be repeated indefinitely. Isothermal curves can be constructed, and the position of the change-point depends on the structure of the jelly and the constitution of the cell-walls, which differ according to the concentration of the forming solution and the speed and temperature of the drying. The power of absorption of water, alcohol and other vapours is very strongly reduced by heat, and at low redness may be entirely removed; in this case some air-bubbles appear on immersion in water. The present research shows that the density of the cell-walls near the change-point is 2·5 to 3, and that by heating to redness it becomes 2·2, while the cell cavities almost entirely disappear, and the walls become generally impervious. S. R.

1331. *Heat Convection in Liquids.* **J. Boussinesq.** (Journ. de Physique, 1. pp. 65–71, Feb., 1902.)—Suppose a solid body, kept at constant temperature a, to be immersed in an unlimited mass of liquid, of density ρ, initially at temperature 0, the expansibility of which is so small, while gravity is so large, that relative changes of the *volumes* of its parts are negligible though the reduction $\gamma\rho$ of the *weight* of unit volume produced by a rise of 1° is sensible. If u, v, w are the velocity-components and P the non-hydrostatic part of the pressure at the point (x, y, z) where the temperature θ has become stationary, and if $b=(a\gamma K/C)^{\frac{1}{3}}$, $c=(a\gamma C^2/K^2)^{\frac{1}{3}}$, where K, C are the conductivity and the specific heat, then the equations of motion show that θ/a, u/b, v/b, w/b, $P/\rho b$ are definite functions of cx, cy, cz, as is therefore also F/Kac, where F is the flow of heat; whence similar systems, with the surfaces of their solids given by $f(cx, cy, cz)=0$, are readily comparable. Now $Kac=(a^4\gamma KC^2)^{\frac{1}{3}}$, so that for similar systems in the same liquid the flow at the surface varies as $a^{\frac{4}{3}}$; but for the *same* body in gases Dulong and Petit found the flow to vary as $a^{1\cdot233}$, so that the dimensional effect seems to be of the form $a^{-0\cdot1}$ or rather $c^{-0\cdot3}$; hence

the cooling power of different liquids *on the same body* may be taken as proportional to $Kac.c^{-0.3} = Kac^{0.7}$. Another result is that for a thin vertical plate the upward acceleration of the liquid is everywhere approximately proportional to its actual temperature. R. E. B.

1332. *Cooling Power of a Stream.* **J. Boussinesq.** (Journ. de Physique, 1. pp. 71–75, Feb., 1902.)—Suppose a current of fluid to be flowing with constant velocity ν past a body kept at constant temperature a. For this case the equations of the preceding Abstract require modification, and if $\gamma\rho\theta$ is neligible they show that u/ν, v/ν, w/ν, $P/\rho\nu^2$ are functions of jx, jy, jz, where j is a parameter, and that θ/a is a function of these terms and of $jK/C\nu$, as also therefore is F/jaK, which gives Newton's law (see Abstract No. 853 (1902). If the body were an indefinitely large thin plate parallel to the current and bounded by an edge perpendicular to the current, the flux of heat is proportional to $a\sqrt{(KC\nu)}$, where a is the mean temperature-excess of the plate over the fluid. R. E. B.

1333. *Mathematical Treatment of the Second Law of Thermodynamics.* **A. Denizot.** (Ann. d. Physik, 7. 2. pp. 358–368, Feb., 1902.)—A purely mathematical deduction of the Second Law is here attempted. The integrating factor g of the expression $du + pdv$ for the heat expended along a reversible path is obtained by the solution of the equations—

$$-dt/(p + \partial u/\partial v) = dv/(\partial u/\partial t) = d\log g/(\partial p/\partial t);$$

the efficiency also of an infinitely small Carnot's cycle, which the author *assumes* to be of the form dL, is $dt(\partial p/\partial t)/(p + \partial u/\partial v)$; whence he [unjustifiably] concludes that $d\log g = -dL$, and $(\partial u/\partial t)dt = 0$, so that $\partial g/\partial v = 0$, and the desired result follows. R. E. B.

1334. *Irreversible Processes and Planck's Theory.* **S. H. Burbury.** (Phil. Mag. 3. pp. 225–240, Feb., 1902.)—If a material system is divided into parts, $a_1, a_2 \ldots a_n$, and it is assumed that they possess, respectively, energies varying with the time and subject to the condition that their sum is equal to the energy, U, of the system, and further that each emits in time, dt, energy proportional to the corresponding u, it is shown that a function exists necessarily diminishing with the time which may be called the entropy of the system. An account is then given of Planck's theory, and it is shown that the conditions for the transfer of energy between the resonator and wave considered by him are the conditions necessary for the application of the above theorem, and that therefore an entropy function may be expected to exist. The author points out that Planck's proof, that the entropy of the resonator and wave continually increases until a stationary state is reached, appears incomplete, and shows how to supplement it by averaging for all waves and resonators of the same period. He also objects to the term written down by Planck for the change of entropy of the system, and notes that the interchange of energy between systems of different periods, which will take place in accordance with Planck's equation, though at a slower rate than for systems of the same period, requires further investigation. In conclusion, it appears doubtful whether Planck's process is really an irreversible process, as the existence of such a thing as his resonator cannot be proved by experiment, for any actual electric vibration such as he proposes must be accompanied by dissipation of energy. [See also Abstracts Nos. 1660 and 1953 (1901).] W. E. T.

1335. *Man as a Heat-engine.* **N. Zuntz.** (Phys. Zeitschr. 3. pp. 184–185, Feb. 1, 1902.)—Criticism of K. Schreber's paper [see Abstract No. 695 (1902)]. The external temperature cannot be a criterion : a man can do work in air hotter than his body ; a fish can swim in water sensibly of the same temperature as its body. Each muscle fibre is an independent machine. When work is done extra food is consumed ; and 39 to 40 per cent. of the energy of this food is transformed into work, say 31 to 34 into external work and 6 to 7 into extra circulation and respiration work. When the body is at rest the whole of the energy of the food consumed is ultimately converted into heat and there is no appreciable storage of energy ; the energy of the food is primarily expended in keeping up the circulation and respiration, the digestive movements, the movements of contractile cells, the chemical and osmotic activity of glands, and the uniform temperature. In a muscle, an efficiency of 40 per cent. would, with a surrounding temperature of 37°, correspond to an internal temperature of 244° ; the chemical change $C + O_2 = CO_2$ would correspond to one of 10,000. The muscle cannot, therefore, act as a heat-engine. Theories of Engelmann (Ueber d. Ursprung d. Muskelkraft, Leipzig, Engelmann, 1893), Pflüger (Pflüger's Arch. 10, 329, 344, 641), Fick (Pflüger's Arch. 53, 106, and 54, 313), and Bernstein (the same, 85, 271) as to the mechanism of muscle-contraction are referred to. A. D.

REFERENCE.

1336. *Empirical Isotherms of Binary Mixtures.* **P. A. Kohnstamm.** (Konink. Akad. Wetensch. Amsterdam, Versl. 9. pp. 432–437, 1902.)—After discussing the various methods used to determine vapour pressures of binary mixtures and accounting for their defects, the author deduces their empirical isotherms in order to show that the phenomena observed are in strict accordance with current views on binary mixtures. A. G.

SOUND.

1337. *Sound Signals.* **E. Price-Edwards.** (Soc. Arts, Journ. 50. pp. 315–327; Discussion, pp. 327–330, March 7, 1902.)—After referring to the trials made in 1874 under the auspices of the Trinity House Corporation, the author describes the matters requiring test and the instruments available in 1901. The relative efficiency of high and low notes; the relative advantages of one large trumpet or several smaller ones to guard a given arc; the relative merits of the developed forms of sirens and horns; new forms of trumpet; the effect of atmospheric condition—all these are investigated. The testing was done on the steam yacht *Irene*, and the region was from St. Catharine's Point, Isle of Wight. In the trials between different types of siren the disc siren proved superior to the cylinder siren, especially in calm weather. As between reed-horn and siren, the latter proved much superior; and in tests of different types of reed-horn the Stentor instrument proved the best. An elliptical form of trumpet, invented by Rayleigh, gave in conjunction with the siren better results than the ordinary circular form. Mushroom-head trumpets were also found an improvement where it is desired to send the sound out in all directions. The effects of wind, fog, and pitch of the notes are described, and the phenomena of the silent area and sea echoes are referred to.

J. W. P.

1338. *Origin of Tones in an Organ-pipe.* **W. Friedrich.** (Ann. d. Physik, 7. 1. pp. 97–115, Dec., 1901. Rostocker Dissertation.)—There are three distinct investigations in this paper: (1) The condition of the blast of air entering the pipe; (2) the condition of the lips of the pipe; (3) the secondary air-streams in the body of the pipe. The results found are: (*a*) The blast entering the pipe vibrates in unison with the air in the pipe—this was found by a König flame manometer; (*b*) but if the body of the organ-pipe be removed no vibrations occur; (*c*) an air-current sets up one side of the pipe and down the opposite side; (*d*) eddies occur in the centre of the pipe; these can be stopped by introducing a partition along the length of the pipe. A sensitive method of studying the vibrations was to have a circuit including a mercury-contact and two electromagnet coils. Any movement in a fine membrane carrying an iron plate near an electromagnet produces induced currents in the circuit, which make and break the circuit at the mercury cup.

P. E. S.

REFERENCE.

1339. *Experimental Phonetics.* **J. G. M'Kendrick.** (Nature, 65. pp. 182–189, Dec. 26, 1901. Paper read before the British Association.)—This is an interesting *résumé* of experimental research into the nature of spoken sounds, and a very complete guide to the bibliography of the subject.

G. W. DE T.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

1340. *Magnetic Shells Equivalent to Circular Coils.* **T. R. Lyle.** (Phil. Mag. 3. pp. 310–329, March, 1902.)—We are to suppose a coil of n turns with current C wound on a cylinder of radius a, where ξ is the breadth of the wire measured parallel to the axis of the coil, η its thickness, x the distance of a point in the axis from the centre of the coil, and $\rho^2 = a^2 + x^2$. With this notation the writer obtains, using Maxwell's formula for the magnetic potential of the coil at any point in its axis—

$$V = 2\pi n C\left(1 - \frac{x}{\rho} + \frac{\eta^2 x}{24\rho^3} + \frac{\xi^2 - \eta^2}{24\rho^5} a^2 x\right)$$

to a sufficient approximation.

The potential of a circular magnetic shell of radius r concentric and coaxial with the coil is—

$$V' = 2\pi n C \cdot \left\{1 - \frac{x}{\sqrt{x^2 + r^2}}\right\}$$

Now V and V′ are identical if—

$$\frac{1}{r} = \frac{1}{a}\left(1 - \frac{3\xi^2 - 2\eta^2}{24a^2}\right),\quad \frac{1}{r^3} = \frac{1}{a^3}\left(1 - \frac{3(5\xi^2 - 4\eta^2)}{24a^2}\right),\quad \frac{1}{r^5} = \frac{1}{a^5}\left(1 - \frac{5(7\xi^2 - 6\eta^2)}{24a^2}\right), \&c.,$$

and if identical on the axis, they are so at all points external to the coil.

The radius r so determined is called by the writer *the equivalent radius* of the coil. By making $\xi = \eta$ we satisfy the above condition, and we make the cross-section square. Such a coil the writer calls a single-shell coil.

He then proceeds to more general cases of equivalence, especially the case in which $\xi \tau \eta$, and the coil is replaced by an equivalent system of two filaments, placed at distances from the centre $\pm\frac{\xi^2 - \eta^2}{12}$. This is called a double-shell coil. He gives practical methods for measuring the equivalent radii. The determination of the mutual inductance of two coaxial circular coils is reduced to that of finding the mutual potential of the equivalent filaments. The paper concludes with notes on the application of the method to a current balance of the type used by Rayleigh and Mrs. Sidgwick.

S. H. B.

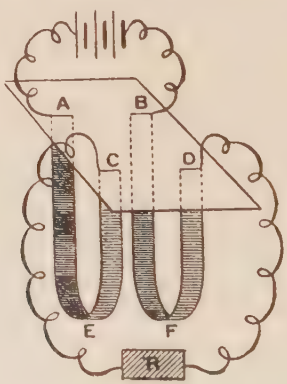
1341. *Boundary Conditions of the Electric Field.* **W. Duane.** (Phys. Rev. 14. pp. 149–157, March, 1902.)—The author's object is to show that the electric charge e being given at each point in space, the potential V is not uniquely determined without some boundary conditions. For if there be two values V_1 and V_2, and $V_1 - V_2 = \phi$, we have by Green's theorem applied to infinite space—

$$\int \left\{\left(\frac{d\phi}{dx}\right)^2 + \&c.\right\} d\tau = \int \phi \frac{d\phi}{d\nu} dS - \int \phi \nabla^2 \phi d\tau = \int \phi \frac{d\phi}{d\nu} dS$$

because the second volume integral is zero. There is nothing, he says, in

Heaviside's fundamental equations to show that the surface integral vanishes, which is necessary in order that we may deduce $d\phi/dx = 0$, &c., and therefore $V_1 = V_2$. In fact, as he says, in the equation $e = \frac{-1}{4\pi}\nabla^2 V$, you may add to V any function f of x, y, z, which satisfies $\nabla^2 f = 0$, *e.g.*, $f = Ax + B$, where A and B are constants. Assuming the total electric energy to be finite, he finds that, if P be the electric force at the bounding surface of a sphere of radius r, Pr must be zero when r becomes infinite. This is the boundary condition. Similar reasoning is applied to the general case of an electromagnetic field. S. H. B.

1342. *The Electrostatic Field surrounding an Electric Current.* **W. de Nicolaiève.** (Comptes Rendus, 134. pp. 33–36, Jan. 6, 1902.)—The author describes experiments made with the apparatus shown in the illustration. The two bands, AEC, BFD, are 8 mm. wide and 30 mm. long, and distant 4 to 5 mm. The battery being put in action, the circuit may be open, C and D, the extremities of the two bands, being insulated, or may be closed by a rheostat of resistance 900 ohms, giving for a battery of 100 volts a current 0·11 of an ampere. With an unclosed current the two bands acquire electric charges of opposite signs and so attract each other. When the circuit is closed by the rheostat the two bands carry currents in opposite directions,



and so tend to repel each other electrodynamically; but it is found (experiment 2) that with the feeble current of 0·11 ampere the result is nearly the same as with the unclosed circuit. The explanation given is that the electrostatic tubes of force continue to exist, but slide along the conductor, diminishing the difference of potential between their extremities. When the resistance of the rheostat is diminished to 200 ohms, and the current proportionally increased, it is found that the repulsive force, varying as the inverse distance, prevails over the attractive force which varies as the inverse square. The apparatus is enclosed in a vertical glass tube, and the results of several experiments are given in which the tube is filled with naphtha or water. Also (experiment 7) for Hertz's two linear conductors are substituted two flexible bands at distances 15–20 cm. It is found that they attract each other powerfully. The author's explanation is that we have here tubes of force sliding by these extremities along the conductors, and this, he says, is the reason why the velocity of propagation is the same in the medium as in the conductors. He holds that the experiments confirm Poynting's theory. S. H. B.

1343. *Rotations Produced by Electric Sparks.* **A. G. Dell.** (Elect. World and Engineer, 39. pp. 300–301, Feb. 15, 1902.)—This paper describes further experiments made by the author of a kind similar to those already described in Abstract No. 1310 (1901), in which it was shown that a lacquered mica disk, suspended on a vertical axle, could be made to rotate by the passage of electric sparks close to it and under it. The effect on the rotations of moisture on the disks and on the supports of the electrodes is now considered, and the author is of opinion that in wireless telegraphy, if the spark-gap and the metal capacities near the gap were as far as possible placed in a box containing dry air, the arrangement would work with greater constancy. W. C. H.

1344. *Atmospheric Electricity in Southern Algiers and near Tunis.* **A. Gockel.** (Phys. Zeitschr. 3. pp. 208–210, Feb. 15, 1902.)—A preliminary account is given of observations taken in August and September, 1901, at Biscra, in the Oasis of Tougourt, and at Hammam el Lif on the seashore near Tunis. The dispersion coefficients were, on the whole, higher in the desert than in Freiburg, Switzerland, 10 per cent. against 5, and the potentials lower, 35 V/*m* against 100 V. The depression went down to 1 per cent. while the potential rose to 150 V, half an hour before sunset in the desert (at Freiburg, after sunset, there was no characteristic change on the seashore) ; this may be connected with the dust and haze which seem to impede the negative ions more than the positive, and with vertical air-currents. A rise in the potential at sunrise was not noticed. Apart from this sudden jump in the evening and the forenoon (9 a.m.) maximum, the potential variations were little marked. On the Mediterranean the potential rose from 30 V/*m* in the early morning to about 80 V ; the average dispersion was 65 per cent. H. B.

DISCHARGE AND OSCILLATIONS.

1345. *Electric Charging and Discharging at a Distance.* **H. Ayrton.** (Nature, 65. p. 390, Feb. 27, 1902.)—An electroscope can be discharged at short distances (15 cm.) by a candle-flame ; at long distances (up to 200 cm.) by an insulated candle-flame towards which an opposite charge is brought and then withdrawn. It can be similarly charged with an insulated candle and a charged rod up to 200 cm. distance. A red-hot platinum wire acts much like a candle up to 300 cm. distance ; apparently this power depends on the presence of some sodium. Insulated cotton-wool dipped in ether, methylated spirit, or dilute sulphuric acid acts as well as the candle-flame and in the same way. Dry carbon dust is ineffectual. A. D.

1346. *Dispersion of Electricity by Evaporation of Liquids.* **H. Beggerow.** (Ann. d. Physik, 7. 3. pp. 494–515, March, 1902. Abstract from the Freiburg Dissertation.)—Blake (Wied. Ann. 19. p. 518, 1883) endeavoured to observe directly any possible electric charge possessed by vapour from electrified liquids, but his results were negative. Schwalbe (Wied. Ann. 58. p. 50, 1896) in a different manner also got negative results. Pellat [see Abstract No. 562 (1899)] with a small insulated brass bowl (beneath a glass bell-jar and joined to a quadrant electrometer of small capacity), charged to 116 volts, found a slightly smaller falling off in potential in a given time when the bowl was dry than when it contained a layer of water, and pointed out that the duration of the experiments of all preceding observers had been much too short, and the capacity of their electrometers much too great. The author has repeated

Pellat's experiment with apparatus similar to his, but with negative results, and has carried out new experiments, taking great care to maintain uniformity of external conditions, and testing those conditions frequently throughout the experiments. This latter test was made by having a second apparatus exactly similar to the first, and so placed that the two must be influenced in exactly the same way by alteration in external conditions. He used in the extended series of experiments a shallow nickel-plated tray whose capacity was from 2·86 to 4 times that of the electrometer, which was of Hankel type, and disconnected from the tray except at the beginning and end of an experiment. The initial potential of the tray was 108 volts, and the time of an experiment 60 minutes ; two observations were made with the tray dry, and then two with the tray moist ; Pellat's results seemed to be confirmed. This was suspected to be possibly due to the fact that the air was always more humid with the tray moist and the insulation therefore impaired. This was found to be the case, and when the author removed this source of error he again got negative results ; the liquids used in the tray were water, ether, alcohol, and sodium chloride solution. The author used also an improved form of Blake's apparatus. A metal plate is kept at constant potential, and above it is an insulated collecting-plate which can contain a freezing mixture. This insulated plate is joined to an electrometer, and receives a charge conveyed through the air from the other plate. The author used two identical pieces of apparatus of this kind, the two collecting plates being joined to the two electrodes of a sensitive quadrant electrometer. Of the two other plates one was dry, the other moist. No deflection of the electrometer needle was found. The liquids used were water, alcohol, common salt solution and radio-active solutions (1 per cent. solutions of acetate and nitrate of uranium). Mercury vapour gives also a negative result. Both positive and negative charges were used in every case. In all the experiments, both by Pellat's and by Blake's method, observations were made with the air at rest and with it in motion, except in the case of mercury, where the air was still. W. S.

1347. *Electrical Conductivities Produced in Air by Motion of Negative Ions.* **P. J. Kirkby.** (Phil. Mag. 3. pp. 212–225, Feb., 1902.)—The author describes experiments showing the remarkable difference in the behaviour of positive and negative ions when moving under electric force in a rarefied gas. As the intensity of the electric field is increased, the negative electrolytic current grows very rapidly, while the positive remains practically stationary. Shown by curves, the negative curve separates itself out from the positive, rising high above it. The author then discusses the theory of the subject, showing that his results are in accord with Townsend's theory of collisions [see Abstract No. 1668 (1901)], and to this extent afford additional evidence of its truth. W. C. H.

1348. *Velocity of Ions drawn from the Electric Arc, II.* **C. D. Child.** (Phys. Rev. 14. pp. 65–74, Feb., 1902.)—The method previously used gave the average velocity of the ions. Two modifications of Zeleny's method [see Abstract No. 2420 (1900)], in which the ions are carried along with a current of air of known velocity, are described, which give the velocity of the fastest and slowest ions. A third method devised by Rutherford, in which an alternating e.m.f. is used of such frequency that the fastest ions reach the surrounding cylinder before reversal, whilst the slower ions fail to reach it, gives the relative velocity of the fastest ions of each kind. In each of the comparisons of the most rapidly moving ions, and also in the comparison

of the average velocities, the positive ions were found to have the greatest velocity, whilst in the comparison of the slowest ions little difference was found between the two kinds of ions. [See also Abstract No. 1308 (1901).]
T. M. L.

1349. *Transition Differences of Potential of the Electric Discharge in Air at Atmospheric Pressure.* **M. Toepler.** (Ann. d. Physik, 7. 3. pp. 477–493, March, 1902.)—This is a continuation of the work referred to in Abstract No. 2020 (1900). The author determines the transition potential differences at which the various forms of discharge, glow, brush, brush-arc and flame-arc begin to occur, and gives an empirical formula for given distance between electrodes, and given diameter of the spherical discharging electrode, the other being a large flat plate. W. S.

1350. *Rate of Recombination of Ions in Gases under Different Pressures.* **R. K. McClung.** (Phil. Mag. 3. pp. 283–305, March, 1902.)—Rutherford (Phil. Mag. Nov., 1897) has shown that if, in any gas exposed to Röntgen rays, the rays be stopped when the rate of production of ions becomes equal to the rate of recombination, the rate at which the conducting particles decay is given by the equation $dn/dt = -\alpha n^2$, where n is the number of ions per c.c. in the gas at time t after the rays have ceased, and α is a constant for any given gas at ordinary atmospheric pressure. The author has in these experiments endeavoured (1) to determine whether this law of recombination holds for air under pressures above and below an atmosphere; (2) if so, to find the relation which α at any given pressure bears to that at any other pressure; (3) to make an absolute determination of α. The results are as follows: (1) The above equation holds good for ionised air, no matter what the pressure may be, at least between the limits of 0·125 of an atmosphere and 3 atmospheres, used in these experiments; (2) α is independent of the pressure of the air for the above range of pressures; (3) the absolute value of this coefficient of recombination for air has been found to be 3384ε, or, substituting the value of the ionic charge, $2{\cdot}20 \times 10^{-6}$. Hydrogen and carbon dioxide were also examined, and the same law of recombination was found to hold true as for air. The coefficient α for carbon dioxide is practically the same as that for air, while the coefficient for hydrogen is only about 87 per cent. of the value for air.
W. C. H.

1351. *Identity of Negative Ions produced in Various Ways.* **J. S. Townsend.** (Nature, 65. pp. 413–414, March 6, 1902.)—The author gives a brief statement of the results of some experiments recently made, which, taken with those of earlier experiments [see Abstracts Nos. 1103 and 1668 (1901)] lead to the following conclusions: The negative ions set free from a zinc plate when ultra-violet light falls on it generate other ions by collisions with molecules of air, carbonic acid, or hydrogen. The negative ions thus generated by collision in the gases have the same properties (over large ranges of pressure and electric force) as the ions generated by the light from the zinc. Thus the four kinds of ions—those given off by the zinc plate, and the negative ions which they produce in air, carbonic acid, and hydrogen—are identical. And finally, the negative ions generated by Röntgen rays in a gas are precisely the same as those set free from a zinc plate by ultra-violet light. The masses of the negative ions from zinc and of those produced by Röntgen rays are the same, and so also are their free paths and charges. Thus it is

possible by various methods to detach from the molecules of gases negatively charged particles, which are small compared with the molecules, and are the same from whatever gas they are removed. W. C. H.

1352. *Stratifications of Hydrogen.* **W. Crookes.** (Roy. Soc., Proc. 69. pp. 399–413, March 21, 1902.)—The author describes experiments made (1) to prepare pure hydrogen, and (2) to investigate the stratifications shown by the pure gas under the influence of an induction current. In the early attempts to prepare the pure gas mercury always showed in the spectrum of the stratifications produced in the gas exhausted to the necessary point. With an improved apparatus and using palladium saturated with hydrogen, the gas at a pressure of 4 mm. gave 12 strata of a concavo-convex button-shape, each blue on the convex side facing the negative pole and pink on the other side. Reversal of the current caused the buttons to reverse also, so that they always presented the blue side to the negative pole. Spectroscopic examination showed hydrogen lines in the pink part, and both hydrogen and mercury in the blue. When the pressure was then reduced to 2 mm. the whole of the blue faces suddenly migrated to form one bright blue, well-formed button nearest the negative pole, leaving the other buttons pink in colour. The spectrum of the blue button showed not a trace of even the brightest hydrogen line, only mercury being detected ; on the other buttons the hydrogen lines were in excess, but mercury could be seen all along the tube. Further efforts were made to eliminate the mercury, and finally, by a process fully described in the paper, pure hydrogen was obtained. The strata now showed no blue whatever, and no mercury lines in the spectrum. They were all pink and gave strong hydrogen lines. If the tube were left overnight connected to the pump, the blue colour appeared in the strata in the morning. If a variable resistance be put in series with the vacuum tube showing, with no resistance interposed, blue and pink strata, then as this resistance is gradually increased the blue colour fades away and soon only pink is seen. Spectroscopic examination again showed that in the parti-coloured strata both mercury and hydrogen were present, while in those of pure pink, while mercury could still be traced, hydrogen was more prominent. These experiments show that the blue colour is due to the presence of traces of mercury. The results with the variable resistance are explained thus : For the same exhaustion hydrogen conducts better than mercury vapour. With a strong induction-spark at a certain reduced pressure the conductivity of the pure hydrogen is insufficient to carry the whole current, and some of it, therefore, is conducted by the mercury vapour. The blue colour then drowns the feebler colour due to hydrogen. But with resistance inserted the current is so weakened that the hydrogen can carry the whole of it, and the blue of the mercury is not seen. The author's explanation of the faces on the pink discs is briefly as follows : Stratifications in mercury vapour are much more difficult to produce than those in hydrogen or other diatomic gases. The hydrogen strata form an anchorage for the mercury, each hydrogen luminosity having a little blue glow of mercury hanging on to it, whereas, if there were no hydrogen present, no mercury would be seen. The pink and blue luminosities show where the electrons and gaseous atoms meet. The dense mercury atom is not driven back so much as the lighter hydrogen atom—hence the blue front to the pink strata. A slight reduction in pressure suffices to break the adhesion between the mercury and hydrogen : then the mercury vapour diffusing along the tube meets the electrons from the negative pole and is swept back to the head of the hydrogen strata and becomes apparent as

a single button of blue light. In conclusion, the author points out that "electrons" are the same as that to which he applied the name "radiant matter" twenty years ago. W. C. H.

1353. *The Doppler Effect and Reversal in Spark Spectra.* **J. F. Mohler.** (Astrophys. Journ. 15. pp. 125–128, March, 1902.)—The author attempts to measure the velocity of the metallic particles driven from the electrodes when the spark is passing between them. The electrodes were of different metals placed in a line perpendicular to the plane of the slit. The spark was first observed when the particles were approaching the slit, and then the electrodes were rotated through an angle of 180°, and the spark again observed. The displacement due to motion of the particles in the line of sight would thus be doubled. Photographs were taken of the spectrum of the spark under the two conditions with a grating, and are reproduced in the paper. The displacement due to the Doppler effect is very small, and the lines are too wide and shaded to allow of any accurate measurements of the velocity. This broadening of the lines is probably due to the rapid decrease in the velocity of the particles owing to repeated collisions very soon after leaving the electrodes, so that an average velocity only was obtained of the order of 0·37 km. per second against Schenk's value of 2·5 km. per second. The most interesting result is the reversal of certain lines, notably the magnesium lines at $\lambda = 2795$, 2802, and 2852, when the spark was going away from the slit; when the spark was coming towards the slit no reversal took place. E. C. C. B.

1354. *Spectrum of the Enclosed Arc.* **L. Bell.** (Elect. World and Engineer, 39. p. 195, Feb. 1, 1902.)—The spectrum of the enclosed arc, whether direct or alternating current, consists almost entirely of the carbon bands with the faintest possible continuous spectrum. E. C. C. B.

1355. *Auxiliary Electrode in Röntgen Ray Bulbs.* **C. E. S. Phillips.** (Roentgen Ray, Archives, 6. pp. 48–54; Discussion, p. 54, Feb., 1902. Paper read before the Roentgen Society, Jan. 2, 1902.)—If an auxiliary electrode is used connected to the anode it should stand behind the antikathode, preferably above it. It is helpful in steadying the discharge and in making the flow of anodic particles more symmetrical about the axis. Its electrostatic action in attracting irregularly moving streams of electrified gas towards it is its greatest function; it tends, on the other hand, to make the condition of the discharge slightly more critical by the additional capacity which it introduces into the circuit: it does not begin to exert an appreciable influence until the gas within the bulb is exceedingly rare, and generally its use becomes more evident after a while when the vacuum has become better. A. D.

1356. *Kathode Discharge in a Magnetic Field.* **H. Pellat.** (Comptes Rendus, 134. pp. 697–700, March 24, 1902.)—The author has shown [see Abstract No. 1094 (1902)] that in an intense magnetic field the ordinary kathode flux (called by him the flux A) delineates the tube of force having the kathode as base. This might be supposed due to the fact that in response to electromagnetic force these rays are wrapped in spiral form round the lines of magnetic force. The author now describes experiments to show that this is not the true explanation of the phenomenon. He uses a straight tube whose axis is horizontal and inclined at 45° to the magnetic

field, which is also horizontal. The experiments range from a pressure of 0·7 mm. to 0·01 mm., with magnetic field intensity varying from 140 to 5,000 c.g.s. For a field of 140 units the action observed is almost that which would be produced by the electromagnetic force alone, the kathode radiation curving up or down according to the sense of the field, its extremity meeting the glass near the vertical plane V through the axis of the tube. As the field increases, the extremity of the kathode pencil simply becomes farther and farther removed from the plane V until it finally lies in a horizontal plane through the axis of the tube; the pencil now delineates the tube of force having the kathode for base, the distinctness of the walls of the tube increasing with the field. If the effect in intense fields were due to wrapping of the kathode rays round the lines of force, then on increasing the field from 140 units we should see the extremity of the pencils describe a large number of narrower and narrower spirals, till each ray represented the line of force embraced by it. The author explains the phenomenon by supposing that the particles constituting the kathode rays experience friction in a magnetic field, the friction being much less in the direction of the lines of force than at right angles to them. That something analogous to friction exists he has proved experimentally as follows: When the pressure is so great that in zero magnetic field the rays do not reach the glass, then in a magnetic field the pencil contracts both along and at right angles to the direction of the field, but considerably more in the latter direction. As the delineation of a tube of force by the flux is as clear in a uniform as in a non-uniform field, the friction cannot be attributed to Foucault currents in the interior of the particles. W. S.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1357. *Electrical Resistance of Steel and Pure Iron.* **C. Benedicks.** (Öfvers. Kongl. Vet. Akad. Stockholm, Förh. 59. No. 2. pp. 67–75, Feb. 12, 1902.)—An extensive series of resistance measurements on eight specimens of Gysinge steel with different percentages of carbon and other impurities leads to the following results:—1. Equivalent portions of various substances dissolved in iron will augment its resistance by equal amounts, as experiments show for the case of C, Si, and Mn, and as may be derived from Wedding's results for the case of P, one dissolved atom per 100 atoms of solution raising it by 5·9 microhms/cm³, in accord with Le Chatélier's measurements. 2. A definite carbide is not found to have any noticeable influence on the resistance of iron. The author, however, suggests that other sorts of steel may exhibit a behaviour somewhat different. 3. Non-tempered steel with 0·45 — 1·70 per cent. C holds 0·27 per cent. C in the dissolved state. Such steels are therefore made up, not of carbide and pure iron, as hitherto supposed, but of a carbide and a 0·27 per cent. solution of carbon in iron, this solution probably being identical with Ostwald's "sorbite." 4. The resistance of steel is represented with great accuracy by the formula $\sigma = 7{\cdot}6 + 26{\cdot}8\,\Sigma C$, ΣC being the sum of the percentages by weight of the "temper carbon" and the value, reduced to carbon, of the remaining substances dissolved. A. G.

1358. *A Modification of Mance's Test.* **J. H. Stephens.** (Electrician, 48. pp. 905-906, March 28, 1902.)—Two tests with different current strengths eliminate the error due to earth current, firstly, by altering battery power or

resistance in battery circuit; secondly, by altering resistance in ratio arms. The author proposes another method, viz., by inserting a resistance in the line circuit when taking the second test, and keeping ratio arms, battery power, and resistance in the battery circuit the same for each test. By making the inserted resistance equal to that of ratio arm *a*, a simple and handy formula is evolved for either even or uneven ratios, which is shown in the paper with diagram. E. O. W.

1359. *Measurement of Insulation Resistance.* **P. Charpentier.** (Écl. Électr. 30. pp. 229–238, Feb. 15, 1902.)—The method of measuring insulation resistance by the loss of charge of a condenser is open to many objections: the pressure on the dielectric is variable, and the time of electrification is indefinite. Further, condensers are not generally available which are capable of withstanding the pressures at which the insulation should be tested, and their insulation resistance may be comparable with that of the dielectric to be tested. The author proposes to avoid these sources of error by forming a condenser of the dielectric. This may have a very small capacity, as high pressures can then be employed. The condenser is charged and left insulated for a time sufficient for the insulation resistance to have reached a constant value. It is then discharged through a galvanometer, and the process is repeated, taking a second discharge after a longer interval. If the capacity of the condenser be known, the resistance may be calculated from the ordinary formula for the loss of charge. The author then discusses at length the variation of resistance with time of electrification, and recommends the measurement after five or six minutes, when the resistance has become constant. G. H. B.

1360. *Capacity of Condenser per Unit of Length.* **K. R. Johnson.** (Öfvers. Kongl. Vet. Akad. Stockholm, Förh. 59. No. 2. pp. 53–57, Feb. 12, 1902.)—In a previous article the author had regarded the capacity of a conducting wire per unit of length as a constant; as, however, this is only approximatively true, a more thorough investigation is made in this paper, the problem being limited to determining a surface of revolution characterised by the property of rendering constant the capacity per unit of length. The author thus shows that this really applies to an ellipsoid of revolution, the constant value of the capacity depending only on the eccentricity of the generating ellipse. Hence, in the case of a wire whose thickness decreases towards the ends, this proposition will be rigorously true, while for an ordinary wire with constant radius, the surface becoming larger than that considered above, the capacity will increase towards the ends. A. G.

1361. *Determination of Dielectric Constants of Crystals in Uniform Fields.* **R. Fellinger.** (Ann. d. Physik, 7. 2. pp. 333–357, Feb., 1902. Extract from the Munich Thesis.)—The chief results of this research are summarised in the following table :—

Substances.	Dielectric Constants.
Quartz	5·0561, 4·6946.
Tourmaline	6·5382, 7·1284.
Calc spar	7·5603, 8·4917.
Baryta	6·9736, 10·0877, 6·9956.
Arragonite	6·0111, 9·1443.
Sulphur (cast)	4·0487.
Paraffin (cast)	2·4574.

E. H. B.

1362. *Electric Dispersion in Dielectrics.* **J. Kossonogoff.** (Phys. Zeitschr. 3. pp. 207–208, Feb. 15, 1902. Habilitation Paper, Kiew, 1901.)—Two parabolic mirrors of cardboard are fixed above one another. They are to reflect waves of a definite wave-length only, and are hence inlaid, parallel to the focal line, with strips of tin-foil; the lengths of these strips were varied in the different sets of experiments. A Righi vibrator and a coherer were used, and the minimum action of the coherer was observed resulting from the interference of the two waves passing through unequal heights of the respective dielectric, liquid paraffin, petroleum, naphtha oil, turpentine, benzene, castor oil. The first five displayed weak normal electric dispersion; the castor oil showed a certain anomaly; this may have been due to water, from which castor oil is hardly ever free. H. B.

1363. *Electrical Testing of Materials.* **P. Holitscher.** (Elektrotechn. Zeitschr. 23. pp. 147–151, Feb. 20, and pp. 170–174, Feb. 27, 1902.)—The author describes the nature of the tests to which Lahmeyer & Co. submit the various materials employed in their manufacture.

Iron.—The hysteresis loss in sheet iron is determined for $B = 10{,}000$ at 50 $\sim$, in watts per kilo. If the loss exceeds 4·4 for 0·5 mm. sheet the author considers the iron should be rejected. A table between B and H is given for specimens of cast steel from three different firms.

Copper.—Directions are given for measuring the conductivity of bare copper. Copper is very uniform in specific gravity; specimens from eleven firms varied only between 8·91 and 8·95, so that the mean section can safely be determined by weighing a given length and assuming a specific gravity of 8·93. In flat strip the edges are always rounded, and the section is consequently less than that calculated from the dimensions. The difference is of the order of 3 per cent. A formula is given from which the true section can be calculated to within about ½ per cent.; if b be the breadth and a the thickness the section is $ab - 0{\cdot}35\,a$. Supplies of copper often differ considerably from the size specified; wire supplied by four firms showed differences of from 7·4 to 15 per cent. of the sizes ordered. The author considers that 3 per cent. divergence is a sufficient margin to allow for solid copper and 6 per cent. for stranded. Cast copper is very variable in quality. Specimens free from blow-holes generally have a low conductivity, and the author has found differences of 100 per cent. in the conductivity of different specimens, although the measurements were made on portions comparatively free from blow-holes.

Insulated Wires.—The author agrees with the recommendations of the Verband Deutscher Elektrotechniker that insulation should be tested by the slope of potential it will stand without rupture, and not by the insulation resistance.

Fuses.—The author tests these by increasing the current by steps, keeping it for one minute at each value. The maximum and minimum currents taken by a number of pieces and expressed in percentages of the rated value gives a clear indication of the uniformity of the fuses.

Insulating materials should be tested by the pressure they will stand, applied between plates and not points. Measurements should be made with the material dry, and with it damp and at different temperatures. Numerous figures are given relating to tests on various materials. The paper concludes with some recommendations on the testing of instruments and meters.

G. H. B.

1364. *New Type of Galvanometer.* **W. Einthoven.** (Archives Néerlandaises, 6. pp. 625–633, 1901.)—The author discusses the condition of maximum sensibility of a d'Arsonval galvanometer, the sensibility being taken to be the deflection in mm. on a scale at a distance of 1 m., produced by a current of 10^{-6} amperes, with an internal resistance of 1 ohm and a period of 5 seconds. The sensibility thus defined is independent of the controlling force and of the winding of a coil of given size, and the author shows it to be a maximum for a coil of as few turns as possible and of the finest wire. In practice the weight of the mirror would falsify this conclusion, but the author, in constructing his galvanometer, dispenses with a mirror and follows the above principle as closely as possible by stretching a silvered quartz thread, 2·1 μ in diameter and 13 cm. long, in a magnetic field of 30,000 units, and projecting a magnified image of the wire on a scale. A current of $1{\cdot}8 \times 10^{-10}$ ampere could be measured, and the galvanometer was dead beat, attaining its full deflection in $\frac{1}{10}$ second. The resistance of the silvered fibre was 20,300 ohms. G. H. B.

1365. *Wehnelt Interrupter.* **A. L. Foley** and **R. E. Nyswander.** (Elect. World and Engineer, 39. pp. 373–374, March 1, 1902.)—The various parts of the interrupter are arranged so that they can easily be separated and reassembled in the same relative positions. For this purpose the wooden base of the apparatus is bored out to receive the cell, and it is provided with a vertical tube which is slotted to form a slide for the arm which carries the anode. The platinum wire anode is held in a clamp formed at the end of the rod by two saw-cuts at right angles to each other; the end of the rod is tapered and a thread is cut so that the clamp can be tightened by a threaded metal ring. It was pointed out by Rossi [see Abstract No. 163 (1900)] that if from any fortuitous cause an interrupter should cease working it can often be made to resume by momentarily breaking the circuit. The authors claim to have discovered this before Rossi, and they describe a cut-out arrangement for effecting the break automatically. As regards electrolytes for interrupters, some work better on high and low voltages than the usual 10 per cent. solution of sulphuric acid. The addition of nitric acid to the sulphuric lowers the voltage required to produce interruptions. On a 115-volt circuit the authors use a 10 per cent. solution of sodic sulphite. With a solution of sodic hyposulphite the interrupter ceased working when the secondary of the induction coil was short-circuited, whereas a solution of ammonic nitrate worked best on a short-circuited secondary. R. A.

ALTERNATING CURRENTS AND MAGNETISM.

1366. *Action of Direct-Current Armatures on Alternating Currents.* **H. Poincaré.** (Écl. Électr. 30. pp. 301–310, March 1, 1902.)—Various general theorems arising out of his previous discussion of this question [see Abstract No. 502 (1902)] are discussed mathematically. The effects of making or breaking a circuit in the neighbourhood of a series of other circuits on the electrokinetic energy of the system are calculated. It is shown that unless we know the signs of the various coefficients of mutual induction, &c., we cannot say whether the electrokinetic energy will be increased or diminished. A. R.

1367. *Charging Currents in Alternating-Current Circuits.* **H. Andriessen.** (Ann. d. Physik, 7. 2. pp. 369–380, Feb., 1902.)—The author describes in this

article a series of experiments made in alternating-current circuits where either large capacities and low frequencies or small capacities and high frequencies were used, and considers the values of the charging current obtained. The author considers also the behaviour of incandescent lamps introduced into similar circuits, or when very high voltages are used, and, lastly, he discusses whether there exists any relation between the voltage, frequency, and danger for the human body, in touching conductors in an alternating circuit. The article is illustrated with diagrams showing the nature of the experiments carried out. The conclusions at which the author arrives are summarised as follows : In an alternating-current circuit of high frequency, a small capacity like a Leyden jar (1 ft. high) introduced into the circuit is sufficient to permit a charging current to pass which should cause a 16-c.p. lamp to burn. Incandescent lamps burn with less current and higher voltage in a high-frequency alternating-circuit than in a direct-current one. With low frequencies the current necessary to make Geissler tubes luminous can pass through the human body without any danger, and, lastly, the human body cannot endure any stronger currents at high frequencies than at low frequencies. (See Elektrotechn. Anzeiger, p. 323, 1898.) L. G.

1368. *Alternate-Current Diagrams.* **W. E. Sumpner.** (Inst. Elect. Engin., Journ. 31. pp. 630–631 ; Discussion, pp. 641–645, March, 1902.)—Mathematical definitions are given of phase angle and power-factor. It is proved that the power-factor can only be unity when the e.m.f. and current waves are similar curves. The fallacy of obtaining a power-factor of unity by means of compensators, and the misleading use of the terms "lag" and "lead" are pointed out. In the discussion the author mentions the necessity of resorting to solid geometry in special cases. A. R.

1369. *Analysing Wave-Forms by Resonance Methods.* **H. Armagnat.** (Écl. Électr. 30. pp. 373–385, March 15, 1902.)—Pupin's resonance method of finding the harmonics in alternating-current waves (American Journal of Science, May, 1893), is improved and amplified. Instead of using an electrometer to find out when resonance takes place at the various harmonics, the author uses an oscillograph or a rheograph. This method has also been usefully applied by T. Mather [see Abstract No. 2289 (1901)]. It is shown that a very small error in adjusting for resonance at a particular harmonic affects appreciably the determination of both the amplitude and the phase of the harmonic : hence good results can only be obtained when the speed of the alternator is very regular. It is advisable to have the time constant of the inductive coil in series with the condenser as large as possible. As a rough guide to the quantity of copper required in the coil the following formula may be used : If T be the time constant required in seconds, then the weight of copper required will be $a(100\mathrm{T})^2$ kg. where a lies between 2 and 3. Oscillograph diagrams of the current are shown when resonance takes place at the fifth, seventh, eleventh, and thirteenth harmonics in the case of a p.d. wave got from a rotary converter. The equation to this curve is approximately—

$$\mathrm{V} = 6{,}500 \sin pt + 136 \sin 5\,pt + 75 \sin\left(7\,pt + \frac{3\pi}{4}\right) + 357 \sin(11\,pt - \pi) + 90 \sin 13\,pt.$$

The curve contains higher harmonics, but their amplitudes are much smaller than those given in the above equation. Instructive diagrams are shown

illustrating the effect of the interference of the other harmonics on the oscillograph record when the circuit is adjusted for resonance at a particular harmonic. To get practically continuous variation of the free period of the system an adjustable induction coil of the Ayrton and Perry type is recommended. A. R.

1370. *The Screening Effect of a Conductor on a Parallel Alternating Current.* **T. Levi-Civita.** (Accad. Lincei, Atti, 11. pp. 163–170, Feb. 16; pp. 191–198, March 2; and pp. 228–237, March 16, 1902.)—In the first of these papers the author considers the case of a current in a rectilinear wire, taken as parallel to x, of finite or indefinite length, and first as alone in space. The components of vector potential, U V W, are calculated as *retarded potentials* of the form $\int \frac{1}{r} f(t - \mathrm{A}r)d\tau$, where $\frac{1}{\mathrm{A}}$ is the velocity of light. The potential of free electricity, F, is calculated according to the same method. The components of magnetic force, L M N, and those of electric force, X Y Z, are subject to the usual formulæ—

$$\mathrm{L} = \frac{d\mathrm{V}}{dz} - \frac{d\mathrm{W}}{dy}, \text{ \&c., and } \mathrm{X} = -\frac{d\mathrm{F}}{dx} - \mathrm{A}\frac{d\mathrm{U}}{dt}, \text{ \&c.}$$

They further satisfy, as the author has previously shown, the conditions—

$$\nabla^2\mathrm{F} - \mathrm{A}\frac{d^2\mathrm{F}}{dt^2} = 0, \quad \nabla^2\mathrm{U} - \mathrm{A}\frac{d^2\mathrm{U}}{dt^2} = 0, \text{ \&c.}$$

It is further assumed that, if $u(t)$ denote the intensity of the current at any point at time t, then the integral $\int_0^\infty \frac{u(t - \mathrm{A}x - \mathrm{A}\lambda) - u(t - \mathrm{A}x)}{\lambda} d\lambda$ where x is the abscissa of the foot of the perpendicular on the current from the point P considered, has a determinate value. Here λ is the sum of the distances of a point x in the wire from P and from x. For the rectilinear current alone in space, the writer arrives at the conclusion that if Q be the foot of the perpendicular from P on the wire, the electromagnetic forces are the same at any instant as if the current were constant, having at each point of the wire the intensity which it has at Q at the instant considered. He finds further $\mathrm{F} = \mathrm{U}$. He next introduces into the field a conducting plane or screen parallel to the current, taken for the plane $z = d$, of specific resistance R, the induced currents in which give rise to retarded potentials, U_1, V_1, W_1, F_1, subject to the same general conditions, as U, V, W, F, the total potentials at any point in the field being now $\mathrm{U} + \mathrm{U}_1$, $\mathrm{V} + \mathrm{V}_1$, &c., and for the current at a point in the screen we have $\mathrm{A}u_1 = -\frac{1}{2\pi}\frac{d\mathrm{U}_1}{dz}$, $\mathrm{A}v_1 = \frac{1}{2\pi}\frac{d\mathrm{V}_1}{dz}$, and the expressions for the electric forces x y give—

$$\frac{d(\mathrm{F}' + \mathrm{F}_1)}{dx} + \mathrm{A}\frac{d(\mathrm{U}' + \mathrm{U}_1)}{dt} = \frac{\mathrm{AR}}{2\pi}\frac{d\mathrm{U}_1}{dz}$$

$$\frac{d(\mathrm{F}' + \mathrm{F}_1)}{dy} + \mathrm{A}\frac{d(\mathrm{V}' + \mathrm{V}_1)}{dt} = \frac{\mathrm{AR}}{2\pi}\frac{d\mathrm{V}_1}{dz}$$

In the second paper the author assumes the current parallel to the screen to be sinusoidal, and of the form $u(t - \mathrm{A}x) = \mathrm{I}_0\epsilon^{i\left(\omega - \frac{\pi}{2}\right)}$, in which $i = \sqrt{-1}$,

and $\omega = 2\pi n(t - Ax) + \alpha$, where n denotes the frequency, and I_0, n, and α are real. The potentials at any point corresponding to this current are—

$$U' = 2I_0\epsilon^{i\left(\omega - \frac{\pi}{2}\right)} \log \frac{1}{d},\ V' = 0,\ W' = 0,\ F' = U',$$

of which, to find the potentials on the screen, we take the real parts. Whence we have—

$$F_1 = 2I_0\epsilon^{i\left(\omega - \frac{\pi}{2}\right)}F_2, \qquad U_1 = 2I_0\epsilon^{i\left(\omega - \frac{\pi}{2}\right)}U_2, \qquad V_1 = 2I_0\epsilon^{i\left(\omega - \frac{\pi}{2}\right)}V_2,$$

F_2, U_2, V_2, being functions of y z. The solution of the problem consists in finding the three harmonic functions F_2, U_2, V_2, of y and z to satisfy the equations—

$$\frac{d^2F_2}{dy^2} + \frac{d^2F_2}{dz^2} = 0,\ \frac{d^2U_2}{dy^2} + \frac{d^2U_2}{dz^2} = 0,\ \frac{d^2V_2}{dy^2} + \frac{d^2V_2}{dz^2} = 0 \quad \text{.....(1)}$$

$$2\pi nAi(F_2 - U_2) + \frac{dV_2}{dy} = 0 \quad \text{.....(2)}$$

and—

$$\left.\begin{aligned} 2\pi nAi(F_2 - U_2) + \frac{AR}{2\pi}\frac{dU_2}{dz} &= 0 \\ \frac{d}{dy}\left(F_2 + \log\frac{1}{d}\right) + 2\pi nAiV_2 - \frac{AR}{2\pi}\frac{dV_2}{dz} &= 0 \end{aligned}\right\} \quad \text{.....(3)}$$

This problem receives a general solution for F_2, U_2, V_2 separately. As an approximate form it is found that $F_2 = -\log\frac{1}{D}$, with $D^2 = y^2 + (z + d)^2$, from which U_2 and V_2 are determinable. These values, however, substituted in the formulæ for U V W, X Y Z, are not convenient for numerical calculations.

In the third paper the author returns to the value of $U_2 - F_2$ given in II., namely, $U_2 - F_2 = i\int_0^\infty \epsilon^{-g\lambda}\frac{d\log\frac{1}{\tau}}{dz}d\lambda$ (equation 15 of Note II.). The second member of this equation has an essential singular point when $g = \infty$. It is shown that for real and positive values of $\frac{1}{g}$ the expression may be expanded by Taylor's theorem, and superior limits found for every remainder. By this means approximate values of F_2, U_2, V_2 are found, approaching the exact value as the number of terms of the Taylor series taken into account is increased.

He then finds superior limits for the errors with which the electromagnetic forces of the field can be affected by the use of the asymptotic approximations. The result given is, that as regards the electric forces on one side of the screen, we may without sensible error take $U_2 - F_2 = 0$. On the far side of the screen the electric forces are sensibly cut off by the screen. Also that on the far side of the screen the magnetic forces are reduced in a certain proportion. S. H. B.

1371. *Measurement of Phase-difference.* **O. Queisser.** (Elektrotechn. Zeitschr. 23. pp. 102–103, Feb. 6, 1902.)—When an alternator with projecting pole-pieces is viewed in the light of an arc lamp in the circuit of the machine, the pole-pieces appear stationary. The apparent position of the pole-pieces

relative to the stationary part depends, however, on the phase-difference between the e.m.f. and current of the arc lamp, and the author proposes to measure this phase-difference by observing the angular displacement of the centres of the armature and field-poles. If the arc lamp be connected in series with the machine, the displacement measures the phase-difference in the circuit. G. H. B.

1372. *Magnetic Properties of Very Thin Sheets of Iron and Nickel.* **C. Maurain.** (Journ. de Physique, 1. pp. 151–156, March, 1902.)—The author gives the results of an examination of the magnetic properties of thin deposits of iron or nickel made on kathodes of brass, silver, copper, gold, and platinum in a magnetic field. It is found that the nature of the kathode has no influence on the results obtained. In the case of iron, the lowest limit of thickness of a layer having definite magnetic properties is about 83 $\mu\mu$ (10^{-6} mm.). The slight initial deviation from a straight line, of the curve representing the deflection of the magnetometer as a function of the time, practically disappears if the strength of field is sufficiently intense, *i.e.*, the magnetic saturation of all the layers corresponds with the same value of the intensity of magnetisation. In the case, however, of nickel, the limiting magnetic layer of which has a thickness of about 200 $\mu\mu$, the intensity of magnetisation of the superficial layers is greater than that of the lower layers. The details of the various experiments are given. T. H. P.

1373. *Calorimetric Properties of Ferro-magnetic Bodies.* **B. V. Hill.** (Elect. Rev. N. Y. 40. pp. 403–404, March 29, 1902.)—Many alloys containing Ni, Co, Mn, Fe were tested as to susceptibility and specific heat at various temperatures from $-180°$ C. to $+1{,}000°$ C., and after varying previous treatment. The conclusion arrived at is that the greater the permeability the less is the specific heat. P. E. S.

1374. *Secular Variations of Terrestrial Magnetism.* **V. Raulin.** (Annal. Chim. Phys. 25. pp. 289–307, March, 1902.)—This paper is mainly an historical summary. The author adheres to the view which he expressed in 1866, that the magnetic north pole revolves about the geographical pole in about 600 years, approximately on the 70° lat., though the advance of the line of zero declination in North America seems to indicate that the pole is now in lat. 75°. At Paris the declination needle has during the 75 years since 1814 receded exactly as much to the east as it had advanced to the west in the 77 years before 1814. That the inclination is still decreasing would be in accordance with his view, which is that an eccentric magnetic mass of a greater density than the earth's centre lags behind the earth's crust by about 1/600 in the diurnal revolution. He rejects the conclusions which Folgheraiter [see Abstracts Nos. 839 and 1039 (1899)] had drawn from the examinations of ancient Etruscan and other vases. H. B.

1375. *The Relation of the Magnetic Properties to the Electric Conductivity of Magnetic Substances.* **W. Gumlich.** (Elektrotechn. Zeitschr. 23. pp. 101–102, Feb. 6, 1902.)—Gumlich and Schmidt have shown [see Abstract No. 2177 (1901)] that generally small hysteresis loss is accompanied by high electric conductivity, and therefore great dissipation of energy due to Foucault currents, and described experiments with materials in which the reverse is the case. In the present paper the author discusses the experiments published by Barrett, Brown & Hadfield (Scientific Transactions of

the Royal Society of Dublin, Vol. 7, Ser. 2), proving that the magnetic quality of iron can be improved, while the Foucault losses are simultaneously diminished, by the addition of small quantities of certain substances. He introduces corrections neglected in the original paper, and calculates Steinmetz's coefficient η connecting the hysteresis loss E in ergs per c.c. with the induction by the equation $E = \eta . B^{1.6}$. The results are given in the following tables :—

TABLE I.

Specimen.	Percentage of Substances other than Iron.			Resistance per mm./sq. mm.		Magnetic Qualities.					
	Al	C	Si	Unannealed.	Annealed.	B for H = 45	Remanence.	Coercive force.	Max. μ	Hysteresis loss E.	η
1167 D	0·75	0·17	0·10	0·248	0·220	16,500	11,000	2·00	2700	11,620	0·0021
1167 H	2·25	0·24	0·18	0·463	0·390	16,500	11,300	1·87	2950	10,960	0·0019
1167 J	5·50	0·22	0·20	0·781	0·700	13,410	4,500	1·43	1550	6,825	0·0017
Iron B	—	0·03	0·14	0·111	0·109	17,480	10,600	1·66	3100	11,090	0·0018

TABLE II.

Specimen.	Percentage of Substances other than Iron.		Resistance per mm./sq. mm.		Magnetic Qualities.					
	Si	C	Not Annealed.	Annealed.	B for H = 45	Remanence.	Coercive force.	Max. μ	Hysteresis loss E.	η
898 E	2·5	0·20	0·471	0·421	16,640	8,000	0·90	—	—	—
898 H	5·5	0·26	0·688	0·652	16,480	6,900	0·85	4000	6500	0·0011
SCJ	0·07	0·028	0·105	0·102	16,750	9,400	1·66 ?	2800	10,100	0·0017
Iron B	0·03	0·14	0·111	0·109	17,480	10,600	1·66	3100	11,090	0·0018

TABLE III.

Specimen SCJ.			Specimen 898 H.		
B	H	μ	B	H	μ
600	0·37	1600	1240	0·29	4200
3680	1·53	2400	4480	1·43	3140
8200	2·96	2770	10520	2·66	3960
12,880	6·36	2030	13440	6.29	2140
14,400	10·17	1420	13920	10·23	1360
15,450	14·04	1100	14560	14·15	1030
16,000	17·97	890	14900	18·10	820
16,800	27·87	600	15450	28·04	550
17,400	37·79	460	16000	37·97	420

W. S.

1376. *Magnetism in a Rotating Iron Cylinder.* **E. Wilson.** (Roy. Soc., Proc. 69. pp. 435–449, March 21, 1902.)—An iron cylinder, 10 in. long and 10 in. in diameter, is placed, like the armature of a dynamo, between the poles of a strong magnet. Holes ¼ in. in diameter are drilled into the cylinder in such wise that four coils can be wound round portions of the iron at various distances from the axis. The coil ends are brought out through the axles to a terminal board. Each coil has a d'Arsonval galvanometer in its circuit. Hence, when the cylinder is rotated slowly, magnetism diffuses from the outside to the axis of the cylinder; the induction current which arises in each coil is measured on its galvanometer. The independent variables are (1) the whole flux between the poles; (2) the speed of rotation, the periodic times being 360, 180, 20, 45, 22·5 secs. The tables show how screening by the outer layers varies with different speeds. Alternating magnetic forces are also used. By the light of these researches the author briefly considers the three important special cases: (1) The earth's rotation in connection with the 960 year period of terrestrial magnetism; (2) the 1 mm. plate as used in dynamo armatures; (3) an iron molecule 10^{-7} cm. thick. In each case the author can use his experimental results; for, when the dimensions of the rotating cylinder are changed n times, then, if the periodic time of rotation is changed $1/n^2$ times, the induction in like parts of the cylinders remains identical. P. E. S.

1377. *Kirchoff's Theory of Magnetostriction.* **S. Sano.** (Phys. Rev. 14. 158–170, March, 1902.)—Kirchoff's theory is given in Sitzberichte Berlin, p. 137, 1884, Wied. Ann. 24. p. 52, 1885, and Gesammelte Abhandlungen Nachtrag Leipzig (1891). In the present paper the theory is extended to the case where the susceptibility k, and two strain coefficients k' and k'', are functions of the strength of the magnetising force. The writer retains the other assumptions made by Kirchoff, that the solid is initially isotropic, and free from hysteresis and time lag, and that the intensity of magnetisation (A B C) is a function, not only of the magnetising force H, but also a linear function of the strain. He obtains expressions for (A B C) which are linear in k, k', k'', k''', and k'''', and then by application of the conditions for the absence of hysteresis, namely $dB/dx - dC/d\beta = 0$ &c., where $\alpha\ \beta\ \gamma$ are the components of the magnetic force, he finds $k''' = \frac{1}{2}Hdk''/dH$ and $k'''' = 0$. A, B, C, are thus found as functions of k, k', and k''. These reduce to Kirchoff's values by making $dk''/dH = 0$. The result is that on Kirchoff's magnetisation is superposed another whose direction is parallel to the magnetic force, and whose intensity is proportional to dk''/dH, and to the linear dilatation in the direction of the magnetic force. The writer then gives a new investigation of the mechanical forces acting on the solid, from which it appears that Kirchoff's expressions require some modification when k and k' are functions of the strength of the magnetising force. S. H. B.

REFERENCE.

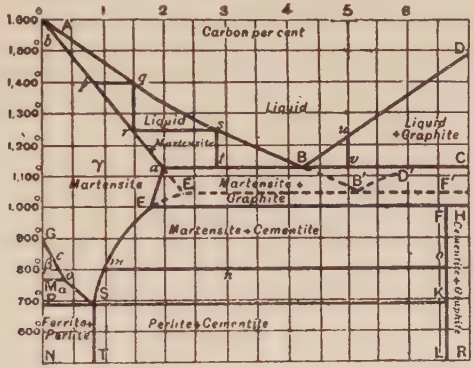
1378. *Ionisation of Gases.* **J. Stark.** (Ann. d. Physik, 7. 2. pp. 417–439, Feb., 1902.)—This paper is a continuation of a previous theoretical paper [see Abstract No. 845 (1901)] on ionisation. It treats of ionisation by collision of ions, of the energy of ions, the work done in ionising them and the efficiency of ionisers, of the effects of temperature and electric force, of stratified and unstratified ionisation in the interior of a gas, and of ionisation at the bounding surfaces of the gas. W. E. T.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1379. *Quantitative Determination of Nitrogen.* **A. Lidoff.** (Jurn. Russk. Fisik. Chimicesk. Obscestva, 34. 1. pp. 42–52, 1902.)—No method of determining directly the percentage of nitrogen in a gaseous mixture has hitherto been devised. The author here describes one which yields fairly satisfactory, though not really accurate, results, based upon the absorbing properties of a mixture of pulverised magnesium and lime. Details of experiments and illustrations of apparatus are given, with tables, from which it appears that the mean limit of accuracy is 93–94 per cent., though in some cases it may be as low as 90 per cent. A. G.

1380. *Ebullioscopic Molecular Weight Determinations in Volatile Solvents.* **G. Oddo.** (Accad. Lincei, Atti, 8. pp. 244–289, 1899 ; 11. pp. 12–20, Jan. 5 ; p. 85, Jan. 19 ; and pp. 130–137, Feb. 2, 1902.)—The boiling-point apparatus finally adopted for these determinations was the ordinary one, except that the inverted condenser attached to the boiling-tube could be turned through an angle of 180° after a reading of the b.p., and was then in position for the distillation of part of the solution. The distillate was in each case collected and analysed ; the analysis gave the composition of the superincumbent vapour during the determination of b.p., and enabled a correction to be made for any volatility of the dissolved substance with the solvent. The molecular weight was obtained from the formula, $M = c(g_2 - g_1)/d$, where c is the molecular constant for the solvent, g_2 the concentration of the solution, g_1 the concentration of the vapour, and d the elevation of boiling-point. The results of the author's experiments are summarised in the following statements : 1. Iodine in boiling solutions, in carbon bisulphide, benzene, and ethyl alcohol has biatomic molecules, whereas in chloroform and carbon tetrachloride we find, in addition to the biatomic, also tetratomic molecules. There appears to be no connection between the colour of the iodine solutions and the complexity of the grouping of the atoms of iodine. 2. Similar results are obtained with some inorganic halogen anhydrides which tend to polymerise in several solvents at the b.p. This is markedly so with phosphorus oxychloride in carbon tetrachloride and in benzene ; less so with thionyl chloride in chloroform or with phosphorus oxybromide or thiophosphoryl chloride in benzene ; much less so with protochloride of sulphur in benzene. It is to be noted that all these anhydrides present cryoscopically, in benzene solution, simple molecules, even in fairly strong solutions. 3. Attempts to isolate polymeric forms of certain organic derivatives of $POCl_3$ were unsuccessful. The compound $C_6H_5NH \cdot POCl_2$ shows in benzene solution a considerable tendency to polymerise, whereas the phenolic ethers, $C_6H_5O \cdot POCl_2$ and $(C_6H_5O)_3PO$ give, in boiling benzene solutions, simple molecules. 4. Sulphur in boiling carbon tetrachloride gives octatomic molecules. 5. Phosphorus pentachloride in carbon tetrachloride has the formula PCl_5. 6. The mono- and tri-chlorides of iodine —probably on account of dissociation—lower the boiling-point of carbon tetrachloride. D. H. J.

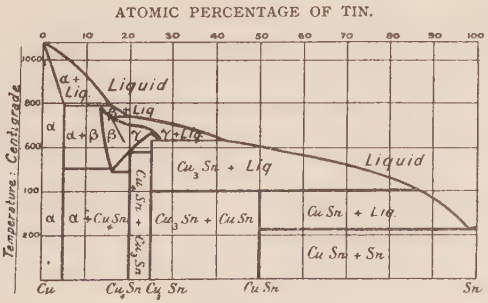
1381. *Alloys.* **W. C. Roberts-Austen** and **T. K. Rose.** (Soc. Arts, Journ. 49. pp. 846–854, Nov. 8; and pp. 858–863, Nov. 15, 1901, Cantor Lectures.)—The papers on which the lectures are based have many of them been already abstracted; the important equilibrium curves for iron and carbon given by Roozeboom [see Abstract No. 2275 (1900)] to explain



the experimental results of Roberts-Austen are given in a compact form and are reproduced herewith.

The general characteristics of eutectic alloys are summarised as follows: When examined under high magnifications they are generally seen to consist of alternate bands of light and dark material. *Perlite*, the eutectic alloy of iron and carbon, consists of *curved bands* of hard cementite (Fe_3C) standing out in relief, with soft ferrite forming furrows between. The eutectic alloy of silver and lead consists of *straight bands* of the two metals. That of iron (89·8 per cent.) and phosphorus (10·2 per cent.) has a *cellular* structure, whilst that of lead (87·3 per cent.) and antimony (12·7 per cent.) has a *spherulitic* structure. Occasionally on slow cooling a crystalline structure is developed. T. M. L.

1382. *Constitution of Copper-Tin Alloys.* **C. T. Heycock** and **F. H. Neville.** (Roy. Soc., Proc. 69. pp. 320–329, Jan. 31, 1902.)—In addition to the pure metals, evidence has been obtained of the existence of three compounds, probably CuSn, Cu_3Sn, and Cu_4Sn, of which the last cannot exist in contact with



the liquid, and of three types of solid solutions of tin in copper, which are named α, β, and γ. Unlike the iron-carbon alloys (preceding Abstract), the pure metal only exists in one modification, and only becomes trimorphous when mixed with tin. The equilibrium between the eight possible phases (one

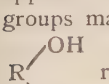
liquid and seven solid) is represented by a diagram similar to that given by Roozeboom for the iron-carbon alloys. This shows that as the percentage of tin is increased the crystals which separate from the liquid are successively the mixed crystals α β and γ, the compounds Cu_3Sn and CuSn, and finally (if there are less than 2 atomic per cents. of copper in the liquid) pure tin. After solidification other changes may take place. The mixed crystals α are stable at all temperatures, and may contain up to 5 atomic percentages of tin. The β crystals may contain from 13 to 20 atomic per cents. of tin, but are only stable between 790° and 480°; below 480° they decompose completely into a mixture of α crystals and the compound Cu_4Sn. The γ crystals are stable only within still narrower limits, between 740° and 580°, and when cooled slowly decompose into a mixture of Cu_3Sn with Cu_4Sn or CuSn, according to the composition of the alloy. The compounds Cu_4Sn, Cu_3Sn, and CuSn are stable at ordinary temperatures, and a copper-tin alloy which is allowed to cool slowly contains only two adjacent phases of the series α (ordinary copper containing dissolved tin) Cu_4Sn, Cu_3Sn, CuSn, Sn; the boundaries which separate these are clearly shown in the Figure. T. M. L.

1383. *The Liquid Crystals of Lehmann.* **A. Amerio.** (N. Cimento, 3. pp. 281–297, Nov.-Dec., 1901. Communicazione al Congresso di Fisica, Bologna, Sept., 1901.)—The substances taken were p.-azoxyphenetol and p.-azophenetol; the latter, which has not previously been studied in this direction, melts at 149° into a turbid liquid becoming clear at 160°. The crystallised solid is strongly birefractive and also dichroic, and in polarised light appears intense yellow or clear green. When melted under the microscope it presents the same phenomena up to the transformation-point 160°, above which it is singly refractive. On gradual cooling, at the point of transformation minute drops, brilliant in the crossed nicols, begin to separate, increasing and uniting to form a parti-coloured field traversed by faint lines. Lehmann attributed [Abstracts Nos. 1876 and 2472 (1900)] this group of phenomena to the "molecular directing force" (Richtkraft) and the resultant orientation in crystals persisting under certain conditions in the liquid state, and that therefore the word "solid" must be omitted from the definition of a crystal. Quincke gave another explanation in the formation of a pellicle of very minute solid crystals, and Tammann [Abstracts Nos. 1352 and 1761 (1901)], pointed out that some emulsions of non-crystalline bodies gave similar appearances. The author re-examines the question, using an apparatus similar to the ice-calorimeter of Bunsen, and incidentally describes his method of projecting the appearances on a screen. The curves demonstrate that at the points of transformation of p.-azoxyphenetol and p.-azophenetol from clear to turbid there is an evolution of heat, and an absorption on the reverse change. The specific heats of both compounds were less in the clear than in the turbid state, as R. Schenk has found with p.-azoxyanisol. The author shows that the formulæ for the melting-point are not all applicable to the point of transformation. Having proved that double refraction and dichroism are properties of the turbid liquids and not due to solid particles, he argues that surface tension is the determining force of the orientation, and that the droplets are not analogous to crystals. He prefers to term them, with Retgers, simply birefractive and anisotropic liquids. S. R.

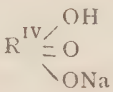
1384. *Existence of Racemic Compounds in Solution.* **G. Bruni** and **M. Padoa.** (Accad. Lincei, Atti, 11. pp. 212–217, March 2, 1902.)—The existence of racemic compounds has so far been proved only for the solid state;

the authors endeavour to show their existence in solution by a cryoscopic examination of the solutions of a racemic compound (dimethyl diacetylracemate), in presence of a large excess of one of the components of the racemate (dimethyl diacetyltartrate). The solvents used were benzene, p.-xylene, ethylene bromide, and bromoform. The freezing-point of the solution of the tartrate was first determined ; the racemate was then added, and the lowering of the freezing-point ascertained. The molecular weights thus found are (except in the case of the bromoform solutions) considerably higher than those of the simple tartrates; so that we have here some evidence of the existence of racemic compounds in solution. D. H. J.

1385. *Nature of Alkaline Solutions of Metal Hydroxides.* **A. Hantzsch.** (Zeitschr. Anorg. Chem. 30. 3. pp. 289–325, 1902.)—(1) The hydroxides of beryllium, zinc, and lead, as well as stannous and germanous hydroxide, are found to behave as weak or extremely weak acids only, their alkaline salts undergoing in aqueous solution in most cases a most advanced hydrolysis and being stable only in the presence of a large excess of alkali. (2) The acid metal hydroxides in aqueous solution will, even in the presence of an excess of alkali, act as mono-basic acids only, the di-basic salts RO_2Na_2 being most probably entirely decomposed into mono-salts and free alkali in aqueous solution. The author thinks such statements as would suggest the presence of polyvalent metal ions, *e.g.*, ZnO_2, entirely invalid. (3) The strength of the acids of these metals has been determined by two methods, the series, beginning with the weakest, being as follows : ZnO_1H_2 ; BeO_2H_2 ; PbO_2H_2 ; SnO_2H_2; GeO_2H_2. This series is divided into two groups. Zinc and beryllium hydroxide behave as extremely weak acids, the former deserving hardly this designation. The remainder, however, are well-defined acids, germanous hydroxide being even a weak electrolyte. The formation of salt in an alkaline lead solution is most considerable, and the amount of alkali necessary to dissolve the hydroxide will be so large only because the hydrolysis of alkaline plumbites has to be nearly completely restrained, so as to prevent the precipitation of the slightly soluble lead hydroxide. (4) As regards the relations between the anions and kations of these metals, a somewhat striking phenomenon is noted. Whereas one would expect the negative electro-affinity of an anion to be the smaller, as the positive electro-affinity of the kation formed of the same metal is greater, this electrochemical rule is verified only for such amphoteric electrolysis as are derived from metals of the same group. When ranging these metals according to strength of kations (as established by H. Ley) and, on the other hand, according to the increasing strength of their anions, the following series are obtained : (*a*) Ge ; Sn ; Be ; Pb ; Zn. (*b*) Zn ; Be ; Pb ; Sn ; Ge. Be and Pb will thus change places. These apparent contradictions will disappear when taking into account the assumption that the salts of the above groups may not correspond to the same structure formulæ, the formula



representing only the salts of the zinc-beryllium group, those of the latter group corresponding to the (formiate) type—



Chemical reasons in favour of this hypothesis are adduced, and the possi-

bility is pointed out that these three metals may not exhibit exclusively the latter type in their alkali solutions, the undissociated proportion of hydroxides as generated by an advanced hydrolysis consisting possibly partly or wholly of di-hydroxides $R(OH)_2$. The hydroxides of the second group are considered as pseudoacids formed with intramolecular transpositions in analogy with certain organic bodies. A. G.

1386. *Solubility of Heavy Metal Hydroxides in Sodium Hydroxide.* **J. Rubenbauer.** (Zeitschr. Anorg. Chem. 30. 3. pp. 331–338, 1902.)—Alkali solutions of the hydroxides of beryllium, zinc, and lead, as well as stannous hydroxide, do not contain any definite compounds (as has since been shown by Hantzsch [see preceding Abstract]), the amount of hydroxide dissolved depending greatly on the concentration of the alkali. The percentage of zinc hydroxide (perhaps also of beryllium) first dissolved will exceed the amount corresponding to the stable condition, a portion depending upon concentration being next separated out. The influence of the concentration of alkali on the solubility of those hydroxides is relatively small in the case of beryllium and tin, somewhat greater in that of lead, and most considerable for zinc. There is no proportionality between the concentration of sodium hydroxide and the solubility in question, as there corresponds, in most cases, to a certain concentration of alkali practically either a maximum or a minimum of solubility. This points to the coexistence of two opposite chemical processes, viz., a diminution of alkaline solubility with increase of dilution, according to the hydrolysis of the salts formed increasing with increase of dilution and, on the other hand, a diminution of the alkaline solubility, as the concentration of alkali increases, the latter being possibly a consequence of the metal hydroxides produced being partly anhydrised [see following Abstract] by the concentrated alkali and separating out in that state. The fact that non-dissolved stannous hydroxide will pass into anhydrous stannous oxide on being imbibed with very concentrated sodium hydroxide already at low temperature, and that recently precipitated, moist zinc hydroxide when dried and heated (in accordance with Herz results) will pass into a modification insoluble or very slightly soluble in alkali, affords an evidence of this hypothesis, the latter modification being possibly a product containing less water than the hydroxide recently precipitated and not capable of being analysed in this state. A. G.

1387. *Interpretation of Modifications of Metal Hydroxides.* **A. Hantzsch.** (Zeitschr. Anorg. Chem. 30. 3. pp. 338–342, 1902.)—This is a remark on the two papers dealt with in the preceding Abstracts. The author suggests accounting for the fact that certain metal hydroxides, when recently precipitated, will first dissolve readily in alkalis, but after a short time will separate out in a state little soluble in alkalis, by the assumption that a physical alteration of the surface energy, as stated by Ostwald in the case of the yellow and red mercury oxides, takes place, though a chemical modification of the state of hydration may have a certain part in those phenomena. A. G.

1388. *Critical Constants of Higher Hydrocarbons.* **P. A. Guye** and **E. Mallet.** (Comptes Rendus, 133. pp. 1287–1290, Dec. 30, 1901, and 134. pp. 168–171, Jan. 20, 1902.)—The authors have determined the critical data for four substances for which the critical temperatures are high, and they take the opportunity to restate the rules which at present establish the complexity of a body for which the critical data are known. The experimental results treated according to these rules show that durene, diphenylmethane,

diphenyl, and naphthalene do not exhibit molecular complexity. In the second paper the authors give the critical data for methyl phenyl ether, ether phenyl ether, m-cresol, aniline, dimethyl aniline, dimethylorthotoluidine, and for acetonitrile, propionitrile, butyronitrile, capronitrile, benzonitrile. The results show that the aliphatic nitriles are all polymerised at the critical temperature, and the coefficients of polymerisation are the largest yet obtained for any substance. Even benzonitrile shows some polymerisation. Between the boiling and critical points the nitriles show polymerisation. The remaining substances studied do not show any appreciable polymerisation in the critical state or between the critical and boiling-points. D. H. J.

1389. *The System Bismuth Oxide, Nitric Acid and Water.* **G. M. Rutten.** (Zeitschr. Anorg. Chem. 30. 3. pp. 342–406, 1902.)—This is a study of the action of water upon a solution of bismuth oxide in water. The author states that the neutral salt $H^2O(S_{10})$ does not possess any melting-point, as it is decomposed at a temperature of 75·5° into a basic salt and a solution. New salts containing $4H_2O$ and $3H_2O$ respectively and a number of basic salts are found, their composition and crystallic form being analysed. The equilibrium phenomena are next tested, and a number of isotherms and quadruple curves are constructed, by means of which the form of three triple surfaces is determined. From this graphic representation the author draws some conclusions as to the relation between the solubility and formation of the neutral and basic salts, and, on the other hand, the temperature and concentration (in N_2O_5) of the solutions. A. G.

1390. *Velocity of Chemical Reactions.* **H. Euler.** (Öfvers. Kongl. Vet. Akad. Stockholm, Förh. No. 2. 59. pp. 57–65, Feb. 12, 1902.)—This is mainly a polemical paper directed against R. Wegscheider's criticism [see Abstract No. 896 (1902)] on the author's researches in the theory of catalytical reactions [see Abstracts Nos. 1118 (1900) and 1546 (1901)]. The conclusion of the former that the analogy between the saponification of esthers and the hydrolysis of salts, as assumed by the author, is invalid, is shown to be based on a misunderstanding of principles, and the author's statement that catalysis consists of an increase of those kinds of molecules or ions by whose presence the (non-accelerated) reaction occurs, is shown to be identical with a proposition enunciated by Wegscheider only a few weeks before. The author finally goes on to show that the explanation of catalysis by means of intermediary reactions, which has been cited against the correctness of his views, does not in any way impugn it, the two explanations differing only by their degree of simplicity and generality. A. G.

1391. *Instantaneous Chemical Reactions and Ionisation.* **L. Kahlenberg.** (Journ. Phys. Chem. 6. pp. 1–14, Jan., 1902.)—It has generally been assumed that instantaneous reactions between two solutions, giving a precipitate, takes place only between ions, *i.e.*, in electrolytes. The author has tested this view by experimenting with non-electrolytes. The solvent used was carefully purified benzene. The conductivity of this and of the solutions was tested by comparison with that of air, the containing vessel being practically an Arrhenius resistance cell, with a galvanometer in series, the deflection of which was noted first with air and then with the liquid. The most suitable solutes were found to be oleates. The oleates of copper, nickel, and cobalt are readily soluble in benzene and give greenish blue, green and dark red solutions respectively, similar to aqueous solutions. On heating a red solution

of cobalt oleate in toluene it turns blue, regaining the dark red colour on cooling. The conductivity was found to be no greater than of pure benzene. There was no action with sodium, nor with magnesium, aluminium, or zinc in copper oleate. The latter appeared to be polymerised according to boiling- and freezing-point tests. There was therefore no indication of ionisation. A solution of dry HCl in benzene was prepared, and was found to conduct no better than benzene itself. This solution does not attack the dry carbonates of sodium, calcium, or barium, nor metallic magnesium. Zinc, however, is acted upon whether amalgamated or not, and platinum in contact with it makes no difference, no hydrogen being evolved from the platinum. An aqueous solution of HCl appears to act rather less readily on zinc than the solution in benzene, and, of course, gives the voltaic effect with platinum. Magnesium, iron, nickel, cobalt, copper, cadmium, mercury, silver, gold and platinum are not attacked, either alone or in contact with other metals. Zinc and aluminium are slightly acted upon, and lead very slightly. Sodium is attacked fairly rapidly. The chlorides are practically insoluble in benzene. When dry HCl gas is passed into a solution of copper oleate in benzene a heavy brown precipitate of cupric chloride is instantly formed, but there is no perceptible increase in the conductivity. The author gives quantitative analyses of the precipitates from copper, nickel and cobalt oleates, the precipitation in each case being complete. Stannic chloride, phosphorus trichloride, arsenic trichloride, and silicon trichloride are miscible with benzene in all proportions, and give solutions which are insulators, but they each precipitate cupric chloride from solutions of copper oleate in benzene. Complete precipitation requires excess of the precipitant as in aqueous solutions. Dry hydrogen sulphide at once throws down sulphides when passed into benzene solutions of the oleates of copper, nickel, and cobalt. In the case of stannic chloride in benzene, sulphide is formed only on standing a considerable time. This is also true of arsenic trichloride in benzene, but sulphides form almost at once if petroleum ether is the solvent. If a solution of dry HCl in benzene is mixed with one of dry ammonia in the same solvent, a precipitate of ammonium chloride is at once formed, although the dry gases will not react. Yet the solutions are non-conductors. Similarly, the HCl solution reacts with a benzene solution of anhydrous pyridine to form pyridine hydrochloride. It therefore follows that instantaneous chemical reactions are not limited to electrolytes, but can take place in solutions which are insulators. W. R. C.

1392. *Cadmium Standard Cells.* **H. Tinsley.** (Electrician, 47. pp. 991–992, Oct. 18, 1901.)—The author has obtained good results, so far as reproduction goes, by using an inverted form of B.T. cell with very little moisture. A discharge curve is given of a rather large cell discharging through 520 ohms. The cell is fairly portable, being made with an amalgamated platinum plate, but the cadmium amalgam is liable to dissociate if the cell is sent by post.
W. R. C.

1393. *Electro-motive Force of Chlorine-Hydrogen Cell.* **E. Müller.** (Zeitschr. Phys. Chem. 40. pp. 158–168, March 25, 1902.)—Numbers varying from 1·31 volts to 1·417 volts are given by different authors as the decomposition-voltage of normal HCl solution; the most usual value is 1·31 volts, which is also taken as the e.m.f. of the hydrogen-chlorine cell when normal HCl solution is used. Smale [Zeitschr. Phys. Chem. 14. 577 (1894)] found different values of this e.m.f. depending on the strength of the

HCl solution. Normal HCl gave 1·360 volts; N/10, 1·472; N/100, 1·547; and N/1000, 1·621 volts. Later, Smale published a correction in which the e.m.f. of the cell, H/1·0 normal HCl/Cl is given as 1·341 volts. A diagram of the author's apparatus, similar to that used by von Wilsmore, is given. The hydrogen and chlorine were each passed through a Richardson's wash-bottle, filled with HCl solution of the same concentration; thence into the electrode tubes, which also were partially filled with acid of the same strength. The electrodes were of platinum sheet and of equal size: the one in contact with the chlorine was polished, and the other platinised; half of each electrode was allowed to dip into the acid. The electrode tubes were connected by side tubes dipping into a dish of HCl. All the acid used was of the same concentration throughout the apparatus, which was kept at a constant temperature of 25° C. in an Ostwald's thermostat. Poggendorff's compensation method was employed to measure the e.m.f., and a capillary electrometer was used. Measurements were made with acid varying from N/1 to N/1000. The e.m.f. found is then compared with that calculated from the formula—

$$E_c = E_0 - (0{\cdot}0002T) \log C,$$

where E_c is the e.m.f. when the ionic concentration is C, and E_0 the e.m.f. when it is N/1. Considerable differences were found between the numbers from experiment and from calculation, the difference increasing as the strength of the acid diminished. This is due to the following reaction between chlorine and water—

$$Cl_2 + H_2O \rightleftarrows H + Cl + HClO,$$

which results in an increased concentration of the chlorine ions. The author finds the extent to which this reaction takes place, and applies a correction derived from it to his former results. This has the effect of bringing the experimental and calculated values much more nearly into coincidence. The author finally gives the value 1·3660 volts at 25° C. as the e.m.f. of the chlorine-hydrogen cell with normal HCl; if the dissociation coefficent of normal HCl is taken as 0·78, the e.m.f. of a cell with normal ionic concentration would be 1·3532 volts. The e.m.f. is not altered perceptibly by altering the source from which the chlorine is produced, nor by heating the chlorine before passing it into the apparatus. W. C. B.

1394. *Ionic and Thermal Coefficients of Nitric Acid.* **V. H. Veley** and **J. J. Manley.** (Phil. Mag. 3. pp. 118–122, Jan., 1902.)—From previous measurements [see Abstract No. 1171 (1899)] of the conductivities of nitric acid the authors give a table of the values of μ/μ_∞ at 15° for concentrations ranging from 1·3 to 99·97 per cent. The change in the temperature coefficient of conductivity at 96 per cent. strength is ascribed to the formation of the compound $2HNO_3, N_2O_5$. Values of the coefficients of expansion of different concentrations of nitric acid are also given. These values when plotted against percentage composition appear to lie partly on four straight lines and partly on an irregular curve (in the case of the higher concentrations). [See also Abstract No. 124 (1902).] F. G. D.

1395. *Susceptibility of Nickel Amalgams.* **H. Wünsche.** (Ann. d. Physik, 7. 1. pp. 116–141, Dec., 1901. Abstract from the Rostock Dissertation.)—The amalgams were formed by electrolysis of a solution of nickel sulphate, ammonium sulphate and ammonia, with nickel or platinum anode, and a

mercury kathode. Iron, which is generally contained as an impurity in nickel or nickel sulphate, is precipitated from the above alkaline solution. Solid amalgams were formed by electrolysis of a solution of nickel sulphate and mercuric chloride. All the amalgams were unstable, the solid more so than the liquid. The former showed globules of mercury on the surface in two hours, and in two or three days were resolved into mercury, nickel, and nickel oxide. When sealed up in an atmosphere of hydrogen they did not decompose, and could be kept for some time under oil. On heating the amalgam decomposes rapidly.

The susceptibility of amalgams with small percentage of nickel was too small to admit of measurement by the magnetometric method. The author therefore had recourse to St. Meyer's method of determining susceptibility by measurement of the attractive force from the formula $\kappa = 2g\phi/M^2q$ where ϕ is the attractive force in grm., M is the field strength and q is the section of the amalgam in sq. cm. The amalgam was contained in a glass tube 10·5 cm. long, which hung on a Joly balance between the poles of an electromagnet.

The susceptibility increases more rapidly than the percentage of nickel; measured in a field of 8,000 units it is $24{\cdot}9 \times 10^{-6}$ for a 0·5 per cent. amalgam, $121{\cdot}9 \times 10^{-6}$ for a 1 per cent., and $349{\cdot}8 \times 10^{-6}$ for a 3·5 per cent. amalgam, the highest submitted to measurement. The author concludes that the amalgam is a chemical combination and not merely a mechanical mixture.

The 3·5 per cent. amalgam showed the curious property of existing in two different states, one having nearly twice the susceptibility of the other, and being more brittle. The author prepared amalgams of this percentage electrolytically five times under precisely similar conditions; three times the amalgam showed the stronger and twice the weaker magnetism. The higher value found for the susceptibility was $672{\cdot}2 \times 10^{-6}$. This phenomenon did not occur with the amalgams of less percentage, and the author supposes it due to differences in molecular structure. When, however, amalgams of less percentage were formed by diluting this 3·5 per cent. amalgam they gave higher values of the susceptibility than those prepared directly.

Finally the author measured the susceptibility of amalgam when surrounded by solid carbon dioxide at a temperature of $-78°$, but found no difference in its value. The paper contains curves between the susceptibility and the field strength for amalgams of different percentages. G. H. B.

1396. *Persulphates.* **F. M. Perkin.** (Electro-Chemist, 1. pp. 189–190, Aug., 1901.)—An account is given of the discovery and preparation of the persulphates, with a diagram and description of an apparatus for showing their formation. When fairly strong sulphuric acid (50 per cent. to 60 per cent.) is electrolysed, very little oxygen appears at the anode, but the solution shows very strong oxidising properties, due to the formation of persulphuric acid. The ions in the strong acid solution are probably H and HSO_4; this assumption is strengthened by the fact that the acid sulphates $MHSO_4$ also yield persulphates, the ions being M and HSO_4. The yield of both acid and salts is greatly improved by lowering the temperature; thus at $-2°$ C. the yield was 64 per cent.; at 27° C. 33 per cent.; and at 60° C. 0·9 per cent. (Elbs and Schönherr). Persulphuric acid is unstable in presence of H_2SO_4, oxygen being evolved and hydrogen peroxide formed; if the sulphuric acid be removed by adding barium carbonate the solution of persulphuric acid is much more stable. The potassium and ammonium persulphates are the most insoluble of the salts which have yet been prepared, while the barium salt is

soluble in water. Manganous salts are oxidised completely to permanganates in presence of a trace of silver salt, whilst with persulphates lead salts yield the peroxide. It has been suggested that this takes place in the production of lead peroxide in storage batteries, but this is regarded as unlikely. A solution of potassium or ammonium persulphate in strong sulphuric acid is a very energetic oxidiser, thus aniline becomes nitroso-benzene, and acetone yields acetone peroxide. From conductivity experiments the persulphates have the formula MSO_4; although the ammonium salt has probably the double formula (Bredig). W. C. B.

1397. *Electrolysis of Organic Compounds.* **J. T. Hewitt.** (Electro-Chemist, 1. pp. 34–35, Feb.; 68–69, March; 99–100, April; 120–122, May; 170–172, July; and pp. 218–219, Sept., 1901.)—A series of papers containing a full account of the application of electrolytic methods to organic bodies. It is pointed out that there are two distinct types of organic electrolysis; the first, in which the substance—for instance, the salt of an organic acid—is split up into anion and kathion, and in which the anion generally breaks down into various decomposition products, their nature depending on the concentration; and secondly, production of new substances by oxidation and reduction at the anode and kathode respectively. There are also electrolytic methods applied for the destruction of impurities; for instance, the refining of sugar-juice and the maturing of wines. Electrolysis is also applied in the tanning industry. Electrolytic reduction usually follows the same course as chemical reduction under similar conditions; thus in a solution in strong H_2SO_4 nitrobenzene is reduced by zinc to p.-amidophenol, which is also the chief product in the electrolytic reduction of the same solution; again, an alkaline solution of nitrobenzene yields the same products when reduced chemically or by electrolysis. The author divides his paper into parts, dealing firstly with aliphatic and secondly with aromatic bodies, and containing descriptions of processes actually in use, or which promise to be of commercial value. The processes are treated chiefly from the chemical standpoint. In connection with the production of acetylene, besides its use as an illuminant, it is pointed out that it might be converted into hydrocyanic acid by mixing with nitrogen and sparking; also by heating cuprous acetylide with zinc and ammonia ethylene is produced. This is absorbed by strong sulphuric acid giving ethyl sulphuric acid, which, on warming with water, forms alcohol. Iodoform is produced by electrolysis of alcohol in presence of potassium iodide. Chloral also is prepared commercially by electrolysis; this is conducted at a temperature of 100° C. in a still divided into two parts by a diaphragm. The anode is of carbon, and the anode space filled with a concentrated KCl solution; the kathode is copper; alcohol is allowed to flow into the anode space, and is there first oxidised and then chlorinated. The production is 50 grammes of chloral per h.p.-hour. W. C. B.

1398. *Calcium Silicide.* **H. Moissan** and **W. Dilthey.** (Comptes Rendus, 134. pp. 503–507, March 3, 1902.)—On account of the contradictory nature of the published investigations of calcium silicide, the authors have re-examined the body. They prepared it as a grey, friable crystalline mass of metallic appearance (sp. gr. 2·5), by the action of 35 gms. of silicon on an equal weight of lime contained in an electric furnace supplied with a current of 600 amperes at 60 volts. The composition corresponds to the formula $CaSi_2$; calcium silicide, therefore, is analogous to calcium carbide in com-

position. There is little analogy between the two bodies in chemical reactions; so that water, for instance, which energetically attacks calcium carbide with evolution of acetylene, scarcely reacts with calcium silicide with evolution of hydrogen. D. H. J.

1399. *Recent Developments in the Electro-Metallurgy of Iron and Steel.* **M. Ruthenberg.** (Electro-Chemist, 2. pp. 12–20, March, 1902.)—The first part of this paper deals with the electromagnetic purification and enrichment of inferior magnetic iron ores, containing sulphur and phosphorus. If the sulphur is present as pyrites separation is easy; phyrotite, on the other hand, is more troublesome, having nearly the same magnetic permeability as magnetite. Except in the case of iron phosphide, the elimination of phosphorus is easy. Fineness of grinding is an essential feature in magnetic separation, and the author finds that the best results are obtained by carrying out the process under water. A product containing between 65 and 72 per cent. of iron can thus be obtained. The various methods of briquetting finely divided ore prior to blast-furnace smelting are then discussed. The author's own method consists in passing the cleaned concentrates through an electric furnace, the melting zone of which is a magnetic field. The ore is thus melted, and in doing so loses its magnetism, and gathering weight from new molten material constantly added to it, falls out of the magnetic field. The result is an agglomerated coherent, hard, strong, and porous mass, varying from the size of a bean to that of a walnut, and in a suitable condition for the blast furnace. By mixing powdered carbon with the concentrated ore prior to introducing into the electric furnace, a partially reduced mass results, which, when allowed to drop into a soaking-pit for the proper length of time, undergoes cementation, so that steel is produced; the latter is easily remelted and finished in the open hearth furnace. Thus the direct production of steel without the intervention of the blast furnace may be effected. The author indulges in a comparison between his system and that of the blast furnace. Ferruginous beach sands containing titanium are dealt with, resulting in the almost complete elimination of titanium. He finds that he can melt a ton of iron ore with an expenditure of 500 kw. hours, against 3,000 of previous investigators.

The second part of the paper deals with the reduction of ore by direct contact with a heated surface, and not by an electric arc. Transverse plates of low electrical conductivity are placed in the throat of a conical-shaped furnace, the invention of M. R. Conley, the bottom of which ends in a bulb-shaped hearth. By passing a strong current through the plates, they are heated to incandescence, the ore, which is fed in at the top, being thus fused. The hearth of the furnace is kept hot by a belt electrically heated. In the hearth the ore can be treated just as it would be in an open hearth furnace, and steel instead of pig-iron tapped off. The following is the estimated cost of manufacturing steel ingots directly from iron ore in a Conley furnace of 100 tons a day capacity: 5,000 e.h.p. at 15 dollars per year per day, 250 dollars; 30 tons of coke at 2 dollars per ton, 60; 200 tons of 65 per cent. ore at 3·5 dollars per ton, 700; renewals per day, 50; labour, 125 making a total cost of 1,185 dollars. The cost per ton of steel ingots at the furnace is 11·85 dollars.

The following is the estimated cost of manufacturing crucible steel in an electrical crucible furnace, of an output of 24 tons per day of 24 hours Electrical power, 1,250 e.h.p. at 15 dollars per h.p. per year, per day, 62·

dollars ; 12 tons much bar at 28 dollars, 336 ; 12 tons good pig at 16 dollars, 192 ; labour, 65 ; renewals, 25 ; making a total of 680·5 dollars. The cost per ton of crucible steel at the furnace is 28·36 dollars.

The third part of the paper describes the Harmet process for the production of steel direct from the ore. The furnace has an inclined sole, on to which the ore is fed, the necessary air being forced in under pressure. Additional heat is obtained by an electric current being passed through the pasty mass on the inclined sole. The carbon electrodes can be placed in any position, so as to equalise the distribution of heat in the material. As the molten ore flows down the hearth it meets coke, or anthracite, fed by means of a shaft. A third furnace stores the metal and refines it, so that it can be cast in large quantities. The estimated cost of 1 ton of metal produced is £1 3s. 4d., as against £1 13s. 9d. with the Martin process. O. J. S.

1400. *The Raritan Copper Refining Works, U.S.A.* (Scientific American, 86. p. 187, March 15, 1902.)—This is an illustrated description of the large refinery situated at Perth-Amboy, New Jersey. The copper comes into the works in the form of pigs—testing 95 to 99 per cent. Cu from the western smelters. The furnace-house of the Raritan works contains nine refining furnaces of the usual type, five of these being of 50 tons capacity. It also contains four large furnaces, each of 50 tons capacity, for melting down pig-copper to be used as anodes in the electrolytic vats. The treatment in these furnaces works off some of the impurities, and the resulting anode copper contains in some cases 99½ per cent. Cu. The actual casting of the copper from these furnaces is effected by a casting machine, the anode moulds being carried on a frame which moves on a pivot, under the casting ladle. The anodes cast by the machines are 24 in. × 36 in. × 1 in. in thickness ; and are provided with projecting lugs for supporting them in their vats. Twenty-two anodes form a charge for one vat or tank ; these weigh between 4 and 5 tons. The tank-house contains 1,600 depositing tanks, arranged in groups of 400 each. The tanks are worked on the multiple system—vats in series, electrodes in parallel. The vats are 2 ft. × 8 ft. × 3 ft. deep, and when charged contain 22 anodes and 23 kathodes. Circulation of the electrolyte is provided for by arranging the vats in sets, each with a well and pump. The thin kathode sheets are formed in 180 "stripping" vats, 36 hours' deposition being requisite to provide a sheet of the desired thickness.

A travelling crane charges the anodes, fixed in a special form of frame, into the vats. The deposition of copper in these vats is allowed to continue seven days, the kathode sheets are then withdrawn and a fresh set are inserted in the vat. The anodes last from 42 to 43 days, before renewal is required. The deposited copper is taken to the 50-ton refining furnaces, and is turned out in any desired form as 99·88 per cent. Cu. The slimes which collect in the vats are boiled in sulphuric acid to extract the copper. The residue is then washed, dried, and smelted on the hearth of a cupel furnace to obtain gold-silver bullion. The separation or "parting" of the precious metals is effected in the usual way. The power-house at the Raritan works contains five vertical cross-compound condensing engines, each direct coupled to a General Electric Company's generator. The size and capacity of these are not given. J. B. C. K.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

1401. *Flywheels for Slow-speed Engines for Electric Lighting and Traction.* **A. M. Downie.** (Inst. Engin. and Shipbuilders, Trans. 45. pp. 24–38, Nov.; Discussion, pp. 35–67, Dec., 1901.)—The author explains flywheel functions and gives three Figs. of crank effort diagrams with a brief explanation thereof, and the following formula for determining the weight of the flywheel to fulfil certain conditions :—If E be the total energy stored in a flywheel of weight w (supposed to be concentrated at the radius of gyration), when moving with a mean peripheral velocity of v_0 ft. per sec; Δ_E the fluctuation of flywheel energy stored in the flywheel when changing from the minimum velocity v_1 through v_0 to the maximum v_2; w the work done by the engine in one revolution; q the coefficient of speed variation allowable between the maximum and minimum limits; k the coefficient of fluctuation of energy.

$$q = \frac{v_2 - v_1}{v_0} \quad \text{.....(1)} \qquad E = \frac{wv_0^2}{2g} \quad \text{.....(2)}$$

$$\Delta_E = \frac{w}{2g}(v_2^2 - v_1^2) = \frac{w}{2g}(v_2 + v_1)(v_2 - v_1);$$

or—

$$\frac{w}{g} \cdot v_0(v_2 - v_1) = 2Eq \quad \text{.....(3)}$$

But—

$$\Delta_E / w = k, \text{ and therefore } k = 2Eq/w.$$

Also—

$$2E = kw/q, \text{ and } w/g = kw/qv_0^2 \quad \text{.....(4)}$$

The mass of the flywheel is directly proportional to the coefficient of fluctuation of energy and the h.p., and inversely proportional to the coefficient of variation of velocity and the square of the speed. The majority of flywheels are of cast iron with a maximum peripheral velocity of about 100 ft. per sec., or about 80 to 90 ft. per sec. on the mean circumference, the maximum stress due to cent. force being about 1,000 lbs. per sq. in.

For lighting loads, q varies from 1/100 to 1/200.

For lighting alternators in parallel, q varies from 1/200 to 1/300.

For traction, q varies from 1/200 to 1/500.

For traction American practice, q varies from 1/450 to 1/650.

q is sometimes expressed in "Electrical degrees" of variation per impulse :—

Let p = pairs of poles of generator. The number of degrees described by each pair of poles per revolution = 360. The number of degrees described by one engine impulse = $p \times 360$/No. of engine impulses per revolution. If ϕ is put for the permissible total variation in degrees then the ratio S = $\phi \times$ No. of engine impulses per revolution $\times p/360$, which should correspond with q as given above. A common value for ϕ is 6°, a 3° increase or lag from the mean. The coefficient of fluctuation of energy is the most important factor in flywheel design, and for this purpose

crank-effort diagrams must be constructed. Tables are given with values of k and q, and fluctuation of crank effort. Actual design and construction are considered. A discussion followed the reading of the paper. J. T. R.

1402. *Governing High-speed Engines.* **J. Finkel.** (Zeitschr. Vereines Deutsch. Ing. 46. pp. 382–387, March 15, 1902. Paper read before the Westphalian Bezirksvereines, April 10, 1901.)—The author enumerates the causes which limit the speed of trip-valve-gear engines, setting the limit at 90 r.p.m. for Corliss and 125 r.p.m. for drop valves. With positive gears the speed can be much higher. A description of a positive Corliss gear due to Professor Doerpel is given. This gear has expansion valves working in separate chests. The objection is often raised against shaft governors that they give too small an admission and an increased compression when the cut-off is early, the latter point necessitating greater clearance.

Various motions of the eccentric sheave are discussed, and admission, compression, and indicator diagrams are given, including a set which show the effect of governing by (*a*) varying both compression and cut-off, (*b*) throttling only, (*c*) varying cut-off only. Method (*a*) is advocated as the most sensitive and rapid in action. Drawings of several shaft governors are included and a method of varying the tension on the springs to obtain variation of speed is shown. Mathematical theories are not touched upon. R. C. R.

1403. *Comparison of Speeds of Two Rotating Axles.* **G. Gauthier.** (Soc. Int. Élect., Bull. 2. pp. 242–244, March, 1902.)—The author describes an optical method of observing (1) synchronism in the speeds of two motors, (2) the increasing or decreasing variation in the ratio of their speeds, (3) the exact value of this ratio when it is such a fraction as $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, &c. The plan adopted is to fix a mirror on the ends of each of the shafts of the two motors (the positions of which must be suitably arranged), the planes of the mirrors being slightly inclined with respect to the perpendicular to the axis of rotation. A ray of light is allowed to fall upon one of the mirrors, whence it is reflected on to the other one and thence upon a screen, where an image is formed dependent on the ratio of the speeds of the motors. If this ratio is unity, the image is a circle; if it attains a value 2, 3, 4, &c., the projected image is epicycloidal, with a number of loops, internal and external, which is equal to the ratio of the speeds. If the ratio is constant, the image on the screen is motionless; if the ratio alters, the image revolves in one direction or the other until when the ratio again becomes constant, it represents the original ratio increased or diminished by unity. The method is easy to apply and capable of great accuracy; if one of the shafts revolves with a known uniform velocity, that of the other can be studied either with respect to its mean value or to cyclical variations. [See Abstracts Nos. 940 to 945 (1902).] B. P. S.

1404. *Distortion in Boilers Due to Overheating.* **C. E. Stromeyer.** (Engineering, 73. pp. 458–460; Discussion, pp. 434–435, April 4, 1902. Paper read before the Institution of Naval Architects.)—From Professor A. Ledebur's investigation and the author's estimate of the results of A. F. Yarrow's boiler experiments, 4,000° F. is assumed as the maximum furnace temperature obtainable in boilers. Under the action of this temperature the upper half of a cylindrical furnace would expand more than the lower, the total resulting deformation being a difference between horizontal and vertical

diameters of about 2 in. The stresses produced in a water-tube boiler surrounded by that temperature are calculated on the assumption that they are the same as are set up in a plate which is being bulged to a radius of 550 in. calculated by $S_1 = Et(\mu^2 - 1)(\mu + 1/2\rho\mu^3$, where E = modulus of elasticity = 30,000,000 lbs. per sq. in.; t = thickness of plate in inches; ρ = radius of curvature in inches; $1 : \mu$ = coefficient of cross contraction. S_1, therefore, equals 40,000 lbs. per sq. in. $\times t = 17{\cdot}8$ tons per sq. in. $\times t$. The stresses are due to the temperature gradient in the metal and depend on the thickness. If 10,000 lbs. per sq. in. be the maximum permissible strength for a water-tube exposed to internal pressure, P = 200 lbs. with a fire of maximum intensity, the limiting diameter is found as follows: 10,000 lbs. per sq. in. = S = $S_1 + S_2$ = the sum of stresses, $S_1 = 40{,}000 \cdot t$; $S_2 = PD/2t = 200\ D/2t = 100\ D/t$; $10{,}000 = 40{,}000 \cdot t + 100\ D/t$; $D = 100 \cdot t - 400 \cdot t^2$ and $dD/dt = 0 = 100 - 800\ t$. It results that for lesser thicknesses than $\frac{1}{8}$ in. the tube diameter must be smaller than 6·4 in., for greater thicknesses the diameter must be reduced. The heating surfaces are taken as clean in these cases. The remainder of the paper is devoted to considering the effects of the addition of $\frac{1}{10}$ in. thickness of scale, and of $\frac{1}{100}$ in. thickness of grease upon the water side of the boiler surfaces, on the basis of E. M. Bryant's determination of the temperature gradient in transmitting heat through boiler-plates. In transmitting enough heat through 1 sq. ft. to evaporate 20 lbs. water per hour, the temperature gradient will be 40° F. per inch of thickness. In a layer of scale the gradient must be 100 times greater or 4,000° F. difference on either side of a thickness of 1 in., and therefore 400° F. for $\frac{1}{10}$ in. If 140 evaporative units of heat per hour be transmitted the mean temperature of a clean furnace-plate will be 70° F. higher than that of the water. With scale added these temperatures become 410° F., with 20 lbs. evaporation, and 2,870° F. with 140 lbs. evaporation with corresponding increase of stresses. The action of scale and of grease in causing bulging of furnace-flues and water-tubes is then discussed, that of grease being considered in view of various theories of the action which causes the collapse of furnaces, but without any finally satisfactory result being reached. This part of the paper contains, however, much suggestive information as to the time required to overheat metal plates, water hammer in boilers, retarded ebullition, &c.

F. J. R.

1405. *The Automobile and Specialty Co.'s Flash Boiler.* (Automobile Rev. 6. pp. 49–50, March, 1902.)—The boiler is built up of a number of sections which are connected together side by side. Eight of these are employed for a light car of the runabout type. The sections are made of a special steel, having a tensile strength of 70,000 lbs. per sq. in. They resemble hollow drums, 9 in. in diameter and 3 in. across, and are provided externally with vertical ribs which increase their heating surface. Central openings in each end serve to connect them in series with one another and to connect the boiler both with the water feed and with the steam supply pipe. Steel discs are provided inside the sections; these are centrally placed and are half an inch smaller in diameter than the cavities in the drums. The discs compel the water and steam to pass over a greater surface in the generator, and the space between the disc and the section itself is filled with small particles of copper. The sections are connected together by heavy nipples and the boiler is placed horizontally over the heating burner. An automatic feed-water system is used. A pump driven by the engine delivers water from the supply tank into a closed seamless drawn steel tank, communicating with the

one end of the boiler. This latter tank, which is fitted with a pressure gauge, contains air acting as a compressible cushion. The water is free to flow to the generator or to return from it to the tank ; the feed to the boiler therefore depends upon the relative pressure in the tank and in the boiler. The pressure in the tank is kept constant by the combined action of the pump and of a relief valve in its delivery pipe ; the relief valve opens when the pressure rises abnormally, and it returns the surplus water to the supply tank. The fuel feed to the burner is also automatic. The fuel is taken to the burner through a specially constructed copper plug, which is screwed into one section of the boiler. The plug is so arranged that it produces an excess of gas if it is overheated, and the gas thus formed is said to retard the flow of fuel to the plug, reducing the fire. A. G. N.

1406. *Superheated Steam in Engines.* **R. Lenke.** (Inst. Mech. Engin., Proc. 4. pp. 847–853 ; Discussion, pp. 854–864, Sept., 1901. Paper read before the Glasgow Engineering Congress (Section III), 1901.)—The behaviour of superheated steam is similar to that of gases. The thermal capacity of steam is 0·48, therefore little heat is required to superheat it. The heat radiation loss due to working with superheated steam is less than that with saturated steam owing to the lower calorific value of superheat as compared with the latent heat of saturated steam. Superheat increases the volume per unit of weight as shown by Table I. :—

TABLE I.

Pressure.	390° F.	570° F.	750° F.
70	1·1	1·33	1·57
115	1·06	1·29	1·52
170	1·02	1·24	1·46

Owing to increase in volume, superheated steam requires less B.T.U. to produce a given volume than saturated steam at the same pressure. Table II. gives total heat per cubic foot for various pressures :—

TABLE II.

Pressure.	Saturated.	390° F.	570° F.	750° F.
70	233	219	192	175
115	350	337	297	267
170	492	485	432	398

For example, to produce 1 cub. ft. at 115 lbs. and a temperature of 570° F. $(350 - 297)/350 = 15$ per cent. less heat is required than to produce 1 cub. ft. of saturated steam at the same pressure. To obtain full economical benefit the highest temperature safe for superheater and engine is 660° to 700° F., but engines must be specially designed to stand this temperature. The author mentions various parts of engines likely to give trouble with superheat. J. T. R.

1407. *Use of Superheated Steam in Semi-portable Engines.* (Génie Civil, 40. pp. 364–366, March 29, 1902.)—This article describes and illustrates a semi-portable compound engine and boiler, on R. Wolf's system, with superheater attached to the boiler. The superheater is composed of a long length of tube bent into a number of spirals placed on edge one after the other in the path of the hot gases, in a space between the horizontal flame-tubes and the chimney. The ordinary fire-tubes are made shorter than usual, and the first portion of the superheater is within a chamber which is surrounded with the water of the boiler as is the furnace which is formed of a Purves or Morison tube. Steam enters the superheater coils at the chimney end, passes through them in series, and is taken from the coil nearest the tube-plate by a straight tube passing along the space in the centre of the coils to the front end of the casing from which it is led to the engine. The engine cylinders are placed in the steam dome. Tests carried out by Lewicki, Professor at the Ecole Polytechnique of Dresden, in April, 1901, gave the following results :—

Heating surface of the boiler in contact with water ...	31 sq. m.
„ „ superheater „ hot gases	20 „
Grate surface	0·85 „
Diameter of high-pressure cylinder	$0{\cdot}240\frac{1}{10}$ m.
„ low „ „	$0{\cdot}450\frac{8}{10}$ „
Length of stroke	0·480 „

The boiler pressure was about 160 lbs. per sq. in. (12 kg. per sq. m.), the speed of the engine 170 r.p.m., and the effective power 100 b.h.p. In the trials about 108·5 b.h.p. and 118·5 i.h.p. were obtained—the mechanical efficiency being 91·6 per cent. The feed-water was supplied at 35° C., and the saturated and superheated steam were respectively 190·57° and 329·60° C. The mean superheat was 139·03° C. The temperature of the gases at entrance of flue was 215° C. The coal from analysis showed a calorific value of 7,910 calories. The consumption of this coal was 0·648 kg. per e.h.p. Quantity of heat utilised per sq. m. of heating surface of boiler reached 11,662 calories, and per sq. m. of superheater 1916·5 calories. Under these conditions the consumption of steam per i.h.p.-hour was 4·85 kg., and per b.h.p. 5·293 kg.—the calorific efficiency being thus 18·9 per cent. per i.h.p., and 17·3 per cent. per b.h.p. F. J. R.

1408. *Construction and Operation of Cooling Towers.* **J. R. Bibbins.** (Eng. News, 47. pp. 223–226, March 20, 1902.)—The author discusses the improvement in distribution of surface provided in cooling towers, as illustrated in two early forms and in the Worthington tower and an experimental tower built for the Edison Illuminating Company, of Detroit, Mich. The efficiency of the tower depends upon the effectiveness of the cooling surface, as it has been found that the reduction of temperature is almost entirely due to evaporation and not to conduction. The Worthington tower employs tile or galvanised iron tubes of about 2 ft. in length set on end in tiers with sheets of wire netting between the tiers. A stand-pipe in the centre rises above the tubes into the upper air chamber, where it distributes the water in spray from perforated tube arms. In the tower at the Edison Company's Works the cooling surface is entirely constructed of "mats" or grids of timber laths assembled on a substantial backing strip with short separator pieces between the laths. The successive tiers are placed at different angles

so as to prevent the water falling freely without passing over the rough surface of the grids. The water is distributed by perforated tubes branching from the stand-pipe at the top. Records of some tests with this tower are given, and also diagrams with plotted curves to show the relations of the different results to one another and to calculated results. F. J. R.

1409. *Kennicott Water Softener.* (Railroad Gazette, 34. p. 181, March 14, 1902.)—As installed on the Union Pacific Railroad, this apparatus has a capacity of 150,000 gallons per day, and consists of a settling tank, which is a steel cylinder 43 ft. high and 13 ft. in diameter, alongside of which is a lime-water tank 25 ft. long and 3 ft. diameter. The water comes from two artesian wells about 1,000 ft. deep, and is led to the softener through a 6-in. supply pipe. The treated water is drawn off into two 50,000-gallon storage tanks placed about 400 ft. apart. The following analysis shows the water before and after treatment :—

	Grains per gallon.	
	Before treatment.	After treatment.
Silicia	0·79	0·40
Carbonate of Lime	9·86	3·45
Carbonate of Magnesia	3·51	0·20
Sulphate of Magnesia	7·03	None
Carbonate of Soda	1·12	0·29
Sulphate of Soda	4·70	7·80
Chloride of Soda	16·48	14·49
Total Solids	43·49	26·63
Incrusting Solids	21·19	4·05

The steel settling tank has a conical bottom, and from the point where the water enters above there is an inner cone-shaped partition, the diameter increasing downwards. The water flows downwards inside the cone, and ascends between the conical partition and the outer shell to the soft water overflow. This increases the cross-section and gradually diminishes the rate of flow in both directions favouring the deposition of solids. The cone also serves as an oil trap when condensing water is used. Floats and valves regulate the process automatically. For treating 150,000 gallons in 24 hours, 57 lbs. soda ash and 1½ barrels of lime are required on the Union Pacific.

F. J. R.

GAS AND OIL ENGINES.

1410. *Ignition Device for Automobiles.* (Motorwagen, 5. pp. 82–83, March 15, 1902.)—A description is here given of an electromagnetically controlled spark ignition contrivance invented by Herr Hellmann of the Dürr Motor Co. In this device, which is intended to overcome the disadvantages of the mechanical driving connections required with ignition arrangements of the Simons-Bosch magneto type, the "extra" current spark arising on breaking an inductive circuit is utilised for effecting ignition, and for this purpose a circuit is provided containing a battery, and a bell electromagnet which is arranged on the outside of the motor cylinder. The electromagnet actuates a spring-controlled armature, the pivot of which passes through the cylinder end and has attached to it a contact blade forming one of the terminals of the circuit and normally held in engagement with an insulated stud which forms the other terminal. The circuit is made and broken alternately between the stud and movable blade, and the spark

which passes at break due to the attraction of the armature by the electromagnet, causes ignition of the explosive charge. By adjustment of the spring the interruption of the circuit is caused to take place when the current has reached its maximum value, so that a very intense self-induction spark results. J. G.

1411. *Moorwood Bennett Carburettor.* (Automotor Journal, 6. pp. 155–156, Jan., 1902.)—This carburettor for heavy oil engines consists of three concentric metal cylinders, of which the inner cylinder is an air inlet tube, the middle cylinder is the kerosene reservoir, and the outer cylinder forms a jacket for heating the oil by means of the exhaust from the engine. At the lower end of the inner cylinder is an adjustable valve, by means of which the admission of kerosene is regulated. The air, carburetted by passing through the heated kerosene, escapes through holes at the top of the kerosene container into the upper part of the jacket cylinder, and passes thence to the engine cylinder. The upper part of the jacket is separated from the portion through which the exhaust passes, by means of a flange projecting from the middle cylinder. On starting the engine, the apparatus is heated by an external burner. It has been successfully used on a 9-b.h.p. Crossley gas engine converted into an oil engine; at the Sheffield Technical School the engine gave 14 b.h.p when fitted with the oil carburettor. C. R. D'E.

AUTOMOBILISM.[1]

1412. *Mechanical Traction and Electric Lighting in Warfare.* **F. Otto.** (Zeitschr. Vereines Deutsch. Ing. 46. pp. 349–350, March 8, 1902.)—The author advocates in this article the use of traction engines instead of the ordinary horse traction as a better means for quick motion and as more economical. Admitting that to each traction engine are attached five cars, the number of horses dispensed with is 21, and instead of the 10 riders and one officer usually required only four people would have to be employed, viz., two engineers and two stokers. The author suggests that the steam engine is better than gas or oil motors for the purpose, because the necessary fuel could easily be obtained everywhere, whereas in using gas, oil, or benzine motors very large quantities of fuel would have to be carried. The author thinks that if the speed attained exceeds 5 km. per hour on ordinary roads, or 10 km. on level roads, the purpose is well served. A traction engine capable of developing about 20 or 30 h.p., and of a total weight not exceeding 9 tons, would be a suitable one. The author emphasises the great advantages derived from the electric light in the battlefields for the many purposes for which it can be used, and suggests that the traction engine should be so constructed that the power generated should be utilised also for the working of cranes, pumps, or independent dynamos, which should not be placed on the same truck, but should be fixed to independent cars, and coupled to high-speed engines or steam turbines. The necessary steam for these engines or steam turbines should be taken through separate pipes from the boiler of the traction engine. In the event of more light being required occasionally, several cars carrying dynamos should be added. The generated electric power could also be used for driving electric motors for bread-kneading and other mechanical purposes. The author shows that by adopting that system

[1] Electric Automobiles are described in the Section dealing with Electric Traction.

of haulage, for instance, in Germany, by introducing only 500 such traction engines, the number of horses to be dispensed with would be about 10,000, and a reduction of over 3,500 persons, as only 1,000 mechanicians and 1,000 stokers would be sufficient to do the work. In distributing these traction engines all over the country, and making use of them all the year round, either for haulage or lighting the barracks or camps, &c., or for driving machinery, the expenses incurred in their purchase would be a good investment. L. G.

1413. *Overman Steam Car.* (Scientific American, 86. p. 139, March 1, 1902.)—This is a light two-seated vehicle, built on the lines now common to American vehicles of this class, but with various modifications in details. The mechanism is as far as is possible enclosed. An automatic feed-regulator controlled by a thermostat is employed, the feed-pump being driven at a comparatively slow speed from the rear axle ; the stroke of the pump plunger is adjustable. The feed-water is heated by passing through a coil of tubing in an exhaust steam-jacket. An injector is also fitted. Air pressure in the fuel tank is maintained by a steam operated pump under control of the driver. This pump is also automatically controlled by a pressure diaphragm which brings the pump into action if the pressure in the fuel tank falls 4 lbs. below the normal. The boiler is fitted with a fusible plug, the melting of which causes a valve controlling the gasoline supply to close. The boiler is of the vertical fire-tube type, and the engine a two-cylinder vertical, with cylinders 2·5 in. bore × 3 in. stroke. Transmission is by a single-chain gear to the live rear axle. C. R. D'E.

1414. *Schaudel Carriage.* (Locomotion Automobile, 9. pp. 198–201, March 27, 1902.)—In this car a double-cylinder horizontal engine and a three-speed spur change gear are combined to form a single piece of mechanism, the change-gear being enclosed in an extension of the crank chamber. The flywheel is mounted externally to the crank chamber, at one end of the crank-shaft, and the female portion of the cone clutch, at its opposite end, outside the gear-enclosing extension chamber. The male portion of the clutch runs free on the extremity of the crank-shaft when the clutch is out of engagement. The motor is mounted in the car with the crank-shaft at right angles to the length of the frame, and the transmission to the live rear axle is effected by a single-chain drive at one side, external to the frame, the chain pinion being mounted on the male portion of the friction-clutch. Several illustrations of the mechanism are given. [See also Abstract No. 947 (1901).] C. R. D'E.

1415. *Duryea Gasoline Carriage.* (Scientific American, 86. p. 147, March 1, 1902.)—This is a light three-wheeled carriage, the rear wheels being drivers, and the front wheel used for steering. It is propelled by a three-cylinder horizontal engine mounted below the seat of the body. Transmission is effected by an epicyclic gear giving two speeds forward and one reverse, and a final chain drive to the exterior of the differential gear on the live rear axle. The cylinders are 4·5 in. bore × 4·5 in. stroke, and the engine is sufficiently powerful to propel the car on the highest gear under all ordinary conditions. The engine is throttle controlled by varying the lift of the inlet valves. [See Abstract No. 1185 (1902).] Low-tension electric ignition with a magneto machine is employed. C. R. D'E.

1416. *Consumption Trials of Motor Carriages.* (Génie Civil, 40. pp. 349–350, March 22, 1902.)—Tables of results of several recent consumption trials held in France are given. Table I. contains the results obtained in the French Automobile Club trials of petrol cars during the Paris Exhibition of 1900 :—

TABLE I.

		Total weight loaded.	Total Consumption.		Consumption per tonne km.	
			800 km. of road.	34·35 km. of level track.	Road.	Track.
		kilogr.	litres.	litres.	litres.	litres.
Voiturettes	Gladiator	400	48·500	2·250	0·129	0·150
	de Dion-Bouton	560	64·000	3·090	0·139	0·158
	Renault Frères	490	66·000	2·750	0·172	0·159
Voiturettes—weight fr. 400 to 1,000 kg.	Peugeot	750	56·680 pr.687 km.	3·100	0·110	0·120
	Delahaye	689	55·900 pr.682 km.	2·850	0·120	0·122
Light cars—weight fr. 1,000 to 1,500 kg.	Delahaye	1,320	64·750 pr.680 km.	3·680	0·072	0 081
	Gobron-Brillié	1,230	73·000 pr.619 km.	5 000	0·095	0·118
	Rochet-Petit	1,000	71·000 pr.690 km.	3·000	0·102	0·687
Carriages—weight fr. 1,500 to 2,000 kg.	Delahaye	1,420	97·000 pr.697 km.	4·000	0·077	0·080
	Brouhot	1,760	142·000 pr.687 km.	5·000	0·117	0·080
Carriages—weight more than 2,000 kg.	Panhard-Levassor	4,310	241·500 pr.697 km.	3·900 pr. 11 km.	0·081	0·078

Table II. gives the best results for the "*Criterium de l'alcool,*" of October 28, 1900, organised by the "Vélo" from Paris to Rouen, 127 km.

TABLE II.

		Total weight loaded.	Consumption 50 per cent. Alcohol.	
			For 127 km.	Per tonne km.
		kilogr.	litres.	litres.
Light cars	Darracq	540	8·500	0·123
	Clément-Panhard	567	9·000	0·124
Carriages	Gobron-Brillié	1,279	15·000	0·092
	De Diétrich	1,540	19·400	0·099
	Panhard-Levassor	1,280	17·000	0·104

Table III. gives the best results for the "*Course Paris Roubaise*," April 7–8, 1901, 278·64 km.

TABLE III.

		Total weight loaded.	Consumption 50 per cent. Alcohol.	
			For 278·64 km.	Per tonne km.
		kilogr.	litres.	litres.
Voiturettes	Darracq	570	18·000	0·1120
Light cars	Gillet-Forest	725	22·850	0·1120
	Darracq	725	23·300	0·1140
Carriages	Société Nancéenne	1,325	33·000	0·0890
	Panhard-Levassor	1,550	39·450	0·0909
	Delahaye	925	24·000	0·0920
	Delahaye	1,240	34·000	0·0979
	Martha-Bollée	1,535	42·500	0·0988

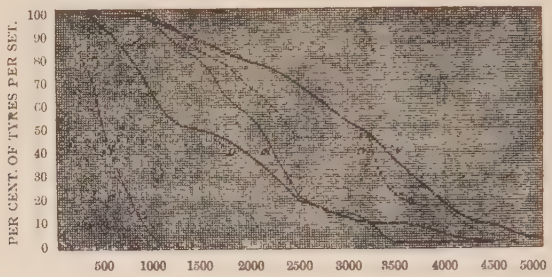
Table IV. gives the best results for the "*Criterium de Consommation*," organised by the "Auto Vélo" on February 5, 1902, and also over the same course on March 5, 1902, distance 100 km.

TABLE IV.

		Poids Total.	Liquide Employé le 5 mars et sa densité à 9°	Consommations du 5 Mars.			Consommations du 5 févr. à la tonne kilomètres.
				totale pour 100 km.	à la tonne-kilomètre.		
		kilogr.		litres.	litres.	kilogr.	litres.
Voiturettes	Peugeot	550	Essence à 690	4,890	0,0889	0,0613	0,1050
	Peugeot	550	Id.	4,900	0.0891	0,0614	0,1060
	G. Richard	510	Essence à 712	5,580	0,1090	0,0776	0,1140
Voitures légères	Darracq	750	Essence à 716	4,850	0,0646	0,0462	0,0876
	De Dion Bouton	865	Essence à 690	6,330	0,0731	0,0504	0,0894
	Korn	733	Id.	5,500	0,0750	0,0517	0,0911
	G. Richard	600	*Alcool à* 50%	4,985	0,0830	,,	0,1027
	Peugeot	1060	Essence à 500	8,890	0,0838	0,0586	0,0888
Voitures	Chenard et Walker	1070	Essence à 714	5,500	0,0514	0,0367	0,0599
	Bardon	918	Essence à 705	6,470	0,0704	0,0496	0,0857
Grosses voitures	Delahaye	2060	Essence à 690	15,130	0,0734	0,0506	0,0943
	G. Richard	1240	Essence à 680	10,000	0,0806	0,0548	0,1085
	Delahaye	1240	Essence à 690	10,650 (pour 60 km.)	0,0858	0,0592	0,1076
Véhicules industriels	De Dietrich	2890	Essence à 698	12,900	0,0744	0,0519	0,0709
	Gillet-Forest	1838	Essence à 716	13,290	0,1208	0,0865	0,0966

The most striking results obtained on the 5th of March being the consumption 0·0514 litres per tonne kilometre for the Chenard & Walker car, and 0·0646 litres for the Darracq light car [see Abstract No. 555 (1901)]. The Chenard-Walker car ran on a mixture of petrol and petroleum sp. gr. 0·714, and the Darracq on petrol of sp. gr. 0·716 + a solution of picric acid dissolved in alcohol. C. R. D'E.

1417. *Tyres for Heavy Vehicles.* **A. L. Stevens.** (Horseless Age, 9. pp. 163–166, Feb. 5, 1902.)—During an extensive experience with pneumatic and solid rubber tyres, the accompanying curves have been plotted from the results obtained with five sets of tyres destroyed on the streets of New York. The tyres were all used on vehicles averaging a little over 2 tons. The curves show the distance after which a given percentage of each set was destroyed. Curve (I) is for a set of 106 5-in. pneumatics (single tube) fixed to the rims by screwed lug bolts. The average cost of these tyres is 12·5 cents per ton mile. Curve (II) is from a set of wired-on solid rubber tyres.



These all tore out from their fastenings, and cost 10 cents per vehicle mile. Curve (III) is from a set of 41 5-in. pneumatics of better quality than set (I), also fixed by screwed lugs. The cost is about 12 cents per vehicle mile. Curve (IV) is from a set of specially heavy walled pneumatics, having small air space and internal layers of sponge rubber. The cost with these was excessive. Curve (V) is from a set of 197 tyres of the same make as set (I), but fixed by projecting pins having freedom to move readily, instead of by fixed bolts ; they cost about 7·75 cents per vehicle mile. During these tests it was clearly established that economy in running was secured by increasing the air pressure in pneumatics from 80 to 125 lbs. per sq. in. The author has used a solid tyre built up of layers of fabric edgewise to the road surface, bedded in a rubber matrix, and vulcanised under pressure, with notable success. C. R. D'E.

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1418. *Silent Chain Gear.* **J. O. Nixon.** (Amer. Soc. Mech. Engin., Trans. 23. No. 929. pp. 373–383 ; Discussion, pp. 383–386, Dec., 1901.)—A description of the chain gear developed by H. Renold, of Manchester, with instances of its application for high-speed driving. H. R. C.

1419. *Modern Practice in Boiler-making Shops.* **E. P. Watson.** (Eng. Mag. 3. pp. 19–44, April, 1902.)

1420. *Waste Heat Engines.* **G. H. Barrus.** (Cassier, 21. pp. 503–507, April, 1902.)

1421. *A Regenerative Accumulator and its Application for using Exhaust Steam.* **A. Rateau.** (Inst. Mech. Engin., Proc. 4. pp. 945–948 ; Discussion, pp. 954–958, Sept., 1901. Paper read before the Glasgow Engineering Congress (Section III), 1901.) J. T. R.

GENERAL ELECTRICAL ENGINEERING.

1422. *American Meter Practice.* **L. C. Reed.** (Amer. Electn. 14. pp. 144–147, March, 1902.)—The author describes in this article the methods used for the measuring of power in alternating-current circuits. The non-inductive meter can be used for either direct or alternating current [see Abstract No. 1561 (1899)]. The induction form of meter used is explained in detail and its application described. The author takes some typical cases of single, two, and three-phase circuits, and indicates by way of diagrams the necessary connections which have to be made in order to measure the true watts. The power in a three-phase circuit may be measured by one, two, or three wattmeters or their equivalent of either the inductive or non-inductive type. For balanced three-phase loads one meter is sufficiently accurate, but when load becomes unbalanced two legs of the circuit must be metered. The case where only one meter is used to measure unbalanced polyphase power-factors is confined to meters of the inductive type, where one or more measuring elements are combined to give a resultant measuring value to a common movable armature. The author describes also the measuring of power on monocyclic systems, in which a regular single-phase circuit is used in conjunction with a third wire called the "teaser," which differs from the single-phase circuit by 90° in phase. In the generator one end of the teaser coil is tapped on to the middle of the single-phase coil, and the other end leads to a collecting ring. That system is adapted to the distribution of light and power, the lights being connected to the single-phase in the usual way. The primaries of the two transformers are placed in series, with the teaser connected to their junction. The secondaries are cross connected, forming a resultant lop-sided three-phase relation, which is used to operate a three-phase motor in the same manner that a regular three-phase system would do. To meter the power passing in the circuit, in using non-inductive meters, one is connected in each outside leg, and the potential circuit is connected between the given leg and the common return. With inductive meters, the regular polyphase meter used for three-phase and two-phase systems is placed in the circuit. The paper is fully illustrated. L. G.

1423. *Correction Coils for Wattmeters.* **R. Beattie.** (Electrician, 48. pp. 818–819, March 14, 1902.)—When the lag in the pressure circuit of a wattmeter is small, the actual reading is $D\left(1 + \frac{L\rho}{R}\tan\theta\right)$, where $L\rho$ and R are the reactance and resistance of the pressure circuit respectively, and D is the true reading. The actual reading then is a linear function of L, and if readings were taken with two different values of L, and the line joining them produced to cut the ordinate at $L = 0$, the value of this ordinate would be the true reading. The author proposes to make use of this principle by providing the wattmeter with a coil of inductance equal to that of the fine-wire circuit, and arranging a two-way switch to put in the circuit either this coil or a non-inductive coil of equal resistance. The error in the reading will then be doubled by introducing the inductive coil into the circuit, and so can be readily measured. The author shows that the accuracy of this method is independent of the wave-form. G. H. B.

1424. *Reports on the Visit of the I.E.E. to Germany in* 1901. (Inst. Elect. Engin., Journ. 31. pp. 534–548; Discussion, pp. 549–573, March, 1902.)—The first report is that of the Committee on Traction, Light, and Power Distribution. In German stations, engines are commonly of the horizontal slow-speed type, running at from 80 to 100 r.p.m. In some cases vertical engines are used; but they are considered to cost more in attendance, and to be higher in prime cost. The enclosed high-speed engine is not used. Water-tube boilers are almost universal, and superheating up to 50° C. is very common, this being effected generally by separately fired superheaters. The bulk of the new work is on the three-phase system. In Berlin, continuous current is distributed; but large stations, containing 90,000 h.p. in three-phase plant, have been built in the suburbs, whence the power is transmitted to central points for distribution and transformation. Very little single-phase or bi-phase work is being done. Inductor alternators are practically extinct. Mention is also made of direct-coupled slow-speed pumping plants. [See also Abstract No. 596 (1902).] The periodicity used is almost always 50; rotaries up to 800 kw. are run at this periodicity in substations in Berlin. The Allgemeine Elektricitäts Gesellschaft used direct-current motors in their old works; but in their newer factories they use three-phase motors throughout, except for driving the cranes in one building, this being done by direct current supplied from motor-generators, which also supply current for inverted arc lighting. At Lahmeyer's works polyphase motors are used for driving groups of machines, while single machines are driven by continuous-current motors. Accumulators are used on a large scale, and amount sometimes to 20 or 25 per cent. of the whole of the plant. An uninsulated middle wire is used on a three-wire system. On tramways, the sliding bow appears to be extending faster than the trolley; it gives a simpler overhead construction at curves and junctions, and more latitude in the position of the overhead wire. The sliding of the bow gives quieter running. The next report is from the Committee on Manufacturing. Small induction motors have short-circuited rotors, and wire resistances in the stator; large motors are started by liquid resistances, usually in the rotor circuit. These resistances consist of lead plates dipping into iron vessels containing a solution of soda. On switchboards high-tension switches are usually fixed behind the board, and worked by insulated levers which are brought through to the front. Very long breaks are allowed, viz., from 10 to 15 in. for 3,000 volts, and 20 to 30 in. for 10,000 volts. Various other details in connection with switchboards and machinery generally are mentioned. Figures are also given relating to the wages paid in Germany. The last report refers to Telephones, and is mainly concerned with a statement of the rates charged in Berlin and the suburbs. The charge for communication in Berlin and the immediate suburbs is £9 a year. In the discussion, **A. Siemens** stated that accumulator traction had proved a failure in Hanover, and that it was now proposed to use the trolley system throughout. On the high-speed experimental railway at Zossen, the speeds had been increased very gradually, and one of 95 miles an hour had now been reached. The experiments about air resistance, which had been made beforehand, had been amply confirmed in actual running. **G. Hooghwinkel** said that an uninsulated middle wire was almost universally used on distributing systems in Germany; the middle wire has usually a sectional area of 25 per cent. of that of the outers. The allowable loss of volts in the middle wire should never exceed 3 volts in any case; and this pressure can cause no danger to gas-pipes. He also contended that with this system the existence of faults was more easily discovered, and the insula-

tion resistance of the system could be kept up to a higher standard. **M. O'Gorman** drew attention to the elaborate precautions which are taken in German cable works with a view to securing cleanliness. The most important particular in which the Germans are ahead of us in the manufacture of cables is the adoption of the vacuum drying and vacuum impregnating tanks. By means of large cast-iron chambers, which are steam-heated, all free moisture is removed from cellulose without exceeding a temperature of 220° F., and without producing any of the partial decomposition of the cellulose, accompanied by the evolution of water, which is brought about by heating for a lengthened period at 240° F. High-tension cables are completely dried on the vacuum system in about 10 hours. Several of the cable works stock only one size of copper wire, and draw it down themselves to suit their requirements. This tends to reduce the amount of capital locked up in copper wire. W. H. S.

1425. *Locating Metals by Electricity.* (West. Electn. 29. pp. 317–318, Nov. 16, 1901.) — Describes a method of locating metallic veins underground which consists in carrying an overground wire across the land to be surveyed, in a series of parallel lines. At the end of each line contacts are inserted, and the resistance between them is measured. It is stated that the fall of resistance, when near a metallic vein running between the contacts, is so great that no difficulty is found in locating a metallic vein. It is stated that an average resistance of 54,000 ohms fell in a particular case to 56 ohms when over a rich copper vein. Other instances are given. Ll. B. A.

1426. *Efficiencies of Electric Cranes.* **R. Matthews.** (Mech. Eng. 9. pp. 348–350, March 15, 1902. Paper read before the Manchester Association of Engineers.)—This paper gives several tables showing the results of tests made on cranes of various powers in operation at Armstrong's works. These tests were carried out under ordinary working conditions, and the figures are the results of a number of trials for each load. Figures relating to the size and construction of the different cranes are also given. With a three-motor 70-ton crane the highest efficiency was reached when hoisting a load of 20 tons at the rate of 3·75 ft. per minute, and was calculated to be 62·8 per cent. With a load of 80 tons the efficiency was 50 per cent., the lifting being done at the rate of 2·56 ft. per minute. With a four-motor 50-ton crane an efficiency of 61 per cent. was shown with a load of 21 tons lifted at the rate of 4·5 ft. per minute, the efficiency at full load being about 45 per cent. An old 40-ton crane driven by an elaborate system of ropes, belts, spurwheels, &c., the whole being worked by a motor, showed at best an efficiency of 16·7 per cent. Other cranes were also tested, and full figures are given in each case, both for hoisting, traversing, and travelling. W. H. S.

1427. *Electric Percussion Rock Drills.* (Eng. News, 46. pp. 130–131, Aug. 29, 1901.)—The paper prescribes three types of percussion drills driven by electric motor. The *Durkee* electric drill has an independent motor of 1½ h.p. driving through a flexible shaft. The motion is given by a special crank which gives a slow return and quick forward or cutting stroke, the driving collar moves the drill spindle through springs so as to cushion the motion if the drill is not striking the rock, and to allow for irregularities in the feed. The drill is rotated by the usual rifled rod and pawl. The machine makes 580 strokes per minute and weighs 230 lbs. without tripod.

The *Gardner* drill is very similar. Instead of a crank a cam is used, so that the forward stroke takes ¼ of a revolution, the backward ¼, and the remaining ¼ it is stationary. The drill is made in 2 sizes, with motors of 1½ and 2 h.p. weighing 150 and 200 lbs. The smaller gives 600 blows with 2½-in. stroke, the larger 500 blows of 3-in. stroke per minute. A special feature is a slipping friction clutch, to avoid blowing the motor fuse if the drill jams in the hole.

The *Hercules* drill endeavours to copy the method of hand drilling. The drill and motor in one frame are carried on a stand. The drill does not oscillate, but is slowly rotated by a rifled bar, being struck at the back by a motor-actuated hammer giving 700 blows per minute. The weight complete with stand is 400 lbs. Ll. B. A.

1428. *Electrically-driven Lathe.* (Engineer, 93 pp. 292–293, March 21, 1902.)—Drawings are given of the headstock of a lathe, constructed by Herbert, and the methods are described by which variations of speed are obtained from a motor running at constant speed. In the first place a step-cone is provided, which gives three changes of speed, and in the second place there is on each of two spindles a pair of friction clutches, which in combination with the step-cone give a range of twelve speeds. The whole of the gearing is enclosed in the headstock, and all the changes of speed are effected by moving levers which are arranged on the outside. W. H. S.

1429. *Electric Hoists on the Comstock.* **L. M. Hall.** (Journal of Electricity, S.F. 11. pp. 205–206, Aug., 1901.)—The author describes a type of electric hoist for lifting ore cars from the incline mines of the Comstock. The special features are, variable speed induction motors with geared hoists, working a continuous rope system, so that there is no unbalanced rope load. The working seems to have been satisfactory, as several plants have been installed. The theoretical h.p. was 66·4, the actual 88·4 h.p., an efficiency of 75 per cent. The total weight lifted is 3,650 lbs., and the speed is from 600 to 1,250 ft. per minute. Ll. B. A.

REFERENCES.

1430. *Edison's Alkaline Accumulators.* **E. J. Wade.** (Electrician, 47. pp. 677–679, Aug. 23, 1901.)—Particulars are given from the patent specifications, of Edison's cadmium copper-oxide cell and iron/nickel-oxide cell, and the author discusses the iron oxides which are used. W. R. C.

1431. *Report on the Visit of the Institution of Electrical Engineers to Germany.* **P. S. Sheardown.** (Inst. Elect. Engin., Journ. 31. pp. 611–627; Discussion, pp. 627–629, March, 1902. Paper read before the Dublin Section of the I.E.E.)—This paper contains a detailed account of the various things that were seen on the occasion of the visit to Germany in June, 1901. W. H. S.

1432. *Wattmeters.* **H. Armagnat.** (Ind. Élect. 11. pp. 5–9, Jan. 10, and pp. 35–37, Jan. 25, 1902).—The author treats first of the dynamometer wattmeter, both of the torsion-head and direct-reading types. He discusses the errors due to mutual induction between the coils, and due to their self-induction and capacity, and shows how to find and correct these errors. He next deals with induction wattmeters and mentions briefly electrostatic instruments. G. H. B.

GENERATORS, MOTORS, AND TRANSFORMERS.

1433. *Equalising Connections in Dynamo Armatures.* **E. Arnold.** (Elektrotechn. Zeitschr. 23. pp. 215–220, March 13, and pp. 233–235, March 20, 1902.)—Any two points in the winding of an armature which are always at nearly equal potentials during the rotation may be connected together, and if there is perfect symmetry in the field there will be no current along such connectors, and hence no object in using them. But since it is impossible to obtain perfect symmetry, the e.m.f.'s induced in the various sections of the winding will in general not balance each other, the current will not be uniformly distributed, and sparking at the brushes will take place. By providing the armature with equalising connectors the out-of-balance currents are made to flow through the connectors instead of passing to the brushes, where they would cause sparking. The author first considers a simplified method of representing a multipolar drum winding by reducing it to an equivalent ring winding. By means of such a "reduced" diagram the equipotential points of the winding are readily determined. The maximum resistance to be given to the equalising connectors in order that they may be effective should correspond to the constant part of the brush contact resistance (this latter may be expressed by a constant, *plus* a term which varies inversely as the current-density). The author states that the use of such equalising connectors has been attended with excellent results, not only in the case of lap-wound armatures, but also in those having unsymmetrical wave-windings, and the Elektricitäts A. G. vorm. Lahmeyer & Co., invariably employs equalising connectors in all the larger machines. Such connectors may be arranged inside the commutator, behind it, in front of or behind the armature, or even along the armature circumference. In the latter case the binding wires may be employed as equalising connectors. The use of such connectors in connection with *wave* windings is patented. A. H.

1434. *Armature Reaction in Alternators.* **E. Arnold.** (Elektrotechn. Zeitschr. 23. pp. 250–252, March 20, 1902.)—The author briefly reviews and criticises the various methods which have been used by different investigators for predetermining the drop which occurs in the armature of an alternator. A number of diagrams are given, including one due to the author and J. L. la Cour. The author explains in detail the calculations necessary in connection with this diagram. Referring to the increase in the leakage coefficient which takes place at full load, he states that this increase does not, in modern machines, exceed some 6 or 7 per cent. A. H.

1435. *Mechanical Strength of Large Alternators.* **H. Linsenmann.** (Elektrotechn. Zeitschr. 23. pp. 81–84, Jan. 30, and pp. 103–107, Feb. 6, 1902.)—The forces tending to produce a deformation of the armature in the flywheel type of generator are partly mechanical, due to the weight of the armature and the torque exerted on it when the machine is running under load, and partly magnetic, arising from the pull exerted on the armature core by each pole-piece. The forces arising from the weight of the armature and the driving torque which acts on it, constitute a stable system—*i.e.*, the increase brought about in these forces by a slight yielding of the armature is

negligible. The forces arising from magnetic pulls, on the other hand, represent an unstable system, since any deformation of the armature (due to want of symmetry) under the action of such forces increases them. The author first calculates the variation of the magnetic pull with the length of air-gap. In the next section of the paper he deduces the general equations connecting the bending-moments of the stable forces with the radial deformation of the armature. Lastly, he takes into account the magnetic forces, and illustrates the practical application of the results obtained by working out a numerical example. A. H.

1436. *The Coupling of Alternators in Parallel.* **R. de Renzis.** (Assoc. Ing. Él. Liège, Bull. 1. pp. 192–210, Sept. 21, 1901. Lecture by M. Motta, read at l'École Polytechnique de Milan.)—The author states that alternators of low frequency work better in parallel than those having a high frequency. It is not always wise to have a too heavy flywheel, since it is not only constancy of speed which regulates stability, but also the lengths of the periods of oscillation of the engine and the alternator. Care must be taken to avoid placing the flywheel too far from the armature, since too long a shaft may act as an elastic connection, and in consequence increase the amplitude of the oscillation. W. G. R.

1437. *The Working of Alternators in Parallel.* **S. Hefter.** (Assoc. Ing. Él. Liège, Bull. 1. pp. 211–268, Sept. 21, 1901. Paper read before the Soc. Electrotechn. de St. Petersburgh, March 12, 1901.)—This is really a short treatise on the working of alternators, the calculations being carried out by graphical methods. The author concludes that alternators work more regularly in parallel the greater the number of poles, or, the frequency remaining the same, the greater the speed of rotation. W. G. R.

1438. *Influence of Speed Regulation of Prime Movers on the Parallel Operation of Alternators.* **C. P. Steinmetz.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 325–328, March, 1902.)—In this paper the author discusses the effect of speed variation of the prime mover—in which class he includes reciprocating engines (steam, gas, or oil), rotary engines (steam or water), and electrical motors—upon the running of alternators in parallel. Three cases are considered—permanent variations of speed due to a change of load, temporary variations due to a sudden change of load, and cyclical variations due to inequality of torque during a revolution. In the case of alternators driven by synchronous motors, an entirely different set of phenomena occurs, the reason for which is explained. Surging or hunting between the alternators is sometimes cumulative or resonating, when the prime mover has a cyclical variation of speed; this can be got rid of, either by breaking the resonance condition of the electric circuit by interference, or by damping the oscillations of the governor, or by reducing the amplitude of the hunting by a damping arrangement in the electric circuit, usually in the field of the alternators. B. P. S.

1439. *Parallel Operation of Engine-driven Alternators.* **W. L. R. Emmet.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 329–335, March, 1902.)—The author believes, contrary to the usual experience, that generators with light flywheels are more easy to operate in parallel than those with heavy flywheels. The rest of the paper deals with the author's dash-pot controller for steam-engine governors. [See Abstract No. 1175 (1900).] B. P. S.

1440. *Self-exciting Alternators.* **M. Latour.** (Ind. Élect. 11. pp. 101–102, March 10, and pp. 121–130, March 25, 1902.)—The author gives an account of the methods proposed by him for constructing a series-wound and a compound-wound self-exciting alternator. In each case, the induced winding of three phases is arranged on the stator core. In the series-wound machine, the three phases of the induced winding are not connected directly, but are joined to three brushes arranged (in a two-pole machine) at 120° from each other around the commutator of the inducing winding, which is identical with that of a continuous-current armature. In the compound-wound generator, the rotor is, in addition to the series winding just mentioned, provided with a shunt winding. The author briefly considers the properties of these machines. [See also Abstract No. 1235 (1902).] A. H.

1441. *Speed Regulation for Direct-Current Motors.* **A. Hundt.** (Elektrotechn. Zeitschr. 23. pp. 235–236, March 20, 1902.)—The author of this article, in reviewing the different systems used for speed regulation with shunt-wound motors, suggests that a better method is to vary the air-gap between the armature and poles of the motor, or, in conjunction with the usual system used, to change the current density passing through the winding of the field magnets. In this way a greater variation of speed, and less sparking at the commutator brushes, is obtained. The author describes in detail a 6-h.p., 500-volt, bipolar motor, having a speed variation from 350 to 1,500 r.p.m. with a constant efficiency of 83 per cent. The variation of air space beween the armature and poles is effected while the motor is in motion. The manner in which this operation is performed, as well as other constructional details, are shown by the author in the illustration accompanying his article. L. G.

1442. *Controller for Polyphase Motors.* **E. Klein.** (Elektrotechn. Zeitschr. 23. pp. 64–66, Jan. 23, 1902.)—The starting resistances, instead of being connected in series and successively cut out till all are short-circuited, are successively put in parallel. A more economical use of the material is thus attained. By permanently connecting one branch of each resistance with one of the contact rings of the rotor, the number of contacts in the controller as well as the number of cables between it and the resistances (in case these are separated) is reduced by one-third. Such a controller, made for the Murnau-Oberammergau three-phase railway, is described and illustrated. A. E. L.

1443. *Rougé and Faget's Rectifier.* **R. Rougé.** (Ind. Élect. 11. pp. 53–56, Feb. 10, 1902.)—Rougé and Faget's rectifier is a kind of rotary converter in which the armature is stationary while the brushes revolve. The alternate current is introduced into a Gramme ring at two points, the windings of the ring being connected up with a commutator. A steel ring with windings supplied with rectified current turns synchronously within the Gramme ring. The shaft carries the rotating brushes and slip-rings for taking off the rectified current. When used for charging accumulators the current is extremely variable, which causes periodic displacements of the neutral line of commutation. To ensure sparkless commutation under such circumstances, each commutator segment is double, one part being connected to one armature winding directly, and the other part through a resistance. The brushes are arranged in two pairs, in parallel, one brush of each pair touching one half of a segment, while the other touches the other half. Curves of the rectified current taken by an ondograph are given. G. H. B.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

1444. *Discussion of Papers on Electric Transmission Systems.* (Amer. Inst. Elect. Engin., Trans. 19. pp. 166-187, Feb., 1902.)—**Shepherdson** concludes from Perrine's statements on the loss by brush discharge, that a solid conductor is preferable to a stranded one, and that aluminium is preferable to copper on account of the larger diameter of the wire. **Fisher** described some experiments contradicting Perrine's statement that the effect of capacity was to flatten the e.m.f. curve. A comparison between effective and maximum values of the e.m.f. were made on a 12,000-volt circuit by measurement of spark distances. When a cable of about 0·3 mf. capacity was connected in parallel the ratio of the e.m.f.'s was greater. **Emmet** thought that Scott had exaggerated the troubles to which synchronous motors gave rise. He did not consider it essential that the excitation of a synchronous motor should be adjusted to conform with change of pressure on the line. With constant excitation it tends to steady the system, and the variation of power-factor with change of load is small. **Steinmetz** thought there was no excuse ever to use an induction motor where a synchronous one could be used. A squirrel-cage motor is ideally simple, but requires the same excessive starting current as a synchronous motor ; if rheostatic control be introduced the motor loses its chief advantage of simplicity. He compares the two types of motor at length, to the advantage of the synchronous motor. **Perrine** showed that under certain circumstances the fact that a synchronous motor can act as generator may be a great advantage. **Stillwell** believed that the synchronous motor possessed one advantage only over the induction motor, namely, in improving the power-factor of the system, but that this advantage was discounted by the necessity for skilled attendants to adjust the fields. He considered that the possibility of synchronous motors falling out of step on a momentary drop of pressure a grave objection to their use. **Mershon,** referring to Perrine's paper on the loss due to discharge from wires at high pressures, said that this loss is a function of the rate of fall of potential at the surface of the wire, which again is a function of the radius of curvature and of the distance between the wires. When this distance is large relatively to the diameter of wire, the rate of fall varies but little with the distance, and depends practically only on the size of wire. The loss will probably depend on the condition of the surface of the wire, and increase as the surface becomes roughened by exposure.

The loss is greatly increased by a peaked wave-form. **Steinmetz** did not think that the loss at very high pressures would depend greatly on the condition of the surface of the wire, or be greater from a stranded cable, though at lower pressures this would be the case ; a very high pressure operates not on the actual surface of the wire, but on the conducting space surrounding it, which is filled with luminous brush discharge. Referring to synchronous and induction motors, he pointed out that the maximum torque of the former varies directly with the pressure, while that of the latter with the square of the pressure ; so that with a decrease of pressure the synchronous motor will maintain its torque longer. [See Abstracts Nos. 2024, 2285 (1901), and Nos. 411, 783, and 1220 (1902).] G. H. B.

1445. *High-frequency Oscillations in High-Potential Transmission Lines.* **P. H. Thomas.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 307–309, March, 1902. Discussion on Steinmetz's paper, Abstract No. 411, 1902.)—Referring to Steinmetz's conclusion that the interruption of a short-circuit may give rise to a p.d. far beyond the strength of any insulating material, the author points out that the assumptions on which this conclusion rests are not sound. A short-circuit is never opened instantaneously, and before a break takes place the current is considerably reduced by the resistance of the arc. Further, if an abnormally high p.d. should be reached on rupturing the circuit, the arc will be re-established. Any device specially designed to give a quick break—for example a magnetic blow-out, air-blast or break under oil—is more likely to cause a dangerous rise of potential than the open-air type of switch. **A. H.**

1446. *High-Potential Surges in Transmission Circuits.* **P. H. Thomas.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 189–240, March, 1902.)—The author gives a non-mathematical account of the various ways in which high-potential waves may arise in a transmission line or the apparatus connected to it. When a "dead" transformer is connected on one side to a high-potential line, one end of its coil is suddenly raised to the full line potential. Each turn of the coil has a certain capacity with respect to the neighbouring turns, and before the various turns have received the charges corresponding to the line potential, the full p.d. between line and earth will exist across the first few turns of the coil; this p.d. may be higher than that which the section of the coil concerned is able to stand, and a tiny spark may pierce the insulation; this spark is so small that it does not produce any permanent damage. If now the second terminal of the transformer be connected to the second line wire, an abrupt change of potential takes place at the corresponding end of the coil, and again the first few turns of the coil at that end may be severely strained; if a spark results, no harm is done so long as the spark is not followed by an arc. The author next considers the charging of a transmission line open at the far end. When such a line is suddenly connected to the terminals of a generator a charging current flows along the line, establishing a p.d. across it corresponding to that of the generator. When the p.d. wave reaches the far end of the line, the current does not stop but is maintained by the energy stored up in the magnetic field of the line. The discharge of this energy increases the p.d. across the far end of the line above the generator p.d., and if the damping due to the resistance of the line be neglected, the p.d. will rise to double the generator p.d. The surplus electrostatic energy due to this higher p.d. now returns to the electromagnetic form, a reflected p.d. wave running back along the line to the generator, where it is once more reflected by the choking effect of the generator coils, and so on. The wave thus runs backwards and forwards, but is soon damped out by resistance. The velocity of such a high-potential wave is so great in comparison with the changes in the generator voltage that the latter may be regarded as constant during the existence of the wave. Lightning is the most frequent source of high-potential surges in transmission lines. It is but seldom that a line is struck directly, and when this occurs near either end of the line probably no form of lightning arrester will offer much protection to the apparatus in connection with the line. The author describes a form of "static interrupter;" this is intended to reduce the potential gradient in a generator or transformer coil, which results from the sudden application of a high potential to one end of it. A simple choking-coil would have such an

effect; but to render it fully effective, a very large amount of copper would have to be used, and the coil would further choke the main current as well. This difficulty is overcome in the author's "static interrupter" by connecting one terminal of a suitable condenser to the junction of a comparatively small choking-coil, the apparatus to be protected with the other terminal of the condenser being earthed. The static interrupter is not intended to supersede the lightning arrester, but to be used in conjunction with it. The arrester should be placed outside the static interrupter, *i.e.*, on the line side of the latter. The function of the static interrupter is to protect apparatus against short-circuit strains; that of the arrester is to discharge the line should the latter acquire too high a potential, and thus to prevent the formation of "earths" in the apparatus connected to the line. In two appendices to the paper, the author describes experiments illustrating the local concentration of potential in a high-tension coil, and a mechanica model illustrating the propagation of high-potential surges in a long transmission line. A. H.

1447. *The Loss of Voltage in Aerial Lines.* **R. de Renzis.** (Assoc. Ing. Él. Liège, Bull. 1. pp. 287–297, Sept. 21, 1901.)—This loss of voltage in aerial lines is shown to be due to the resistance of the line and to self- and mutual induction. In the case of two parallel wires, and self- and mutual induction are calculated and given respectively by $L = 1/2 - 2 \log r$, and $M = -2 \log d$, where r is the radius of either wire and d the distance between the centres of the two wires. W. G. R.

1448. *Electric Wiring System.* **A. Peschel.** (Elektrotechn. Zeitschr. 23. pp. 202–206; Discussion, pp. 206–207, March 6, 1902. Paper read before the Elektrotechnischen Verein, Jan. 28, 1902.)—The author describes his system of wiring, and the specially devised conduit, which not only replaces the ordinary tubing, but acts as a return, insuring perfect contact, and at the same time is virtually earth-connected. The advantages claimed by the author are, firstly, the price, this being much lower than that of the metal tubes usually employed, and as the contact between the different parts making up the conduit is not made through screwing nipples or sockets, &c. the pipes have not to be threaded, and can therefore be made thinner and lighter. The tubes used are made of tinned iron sheets, rolled in such a manner as to leave a longitudinal slot, which permits the tube fitting on to any socket which is a little larger, and making perfect contact. Wall sockets, switch and fuse boxes, as well as other accessories, are carefully designed by the author, as is shown in the illustrations accompanying the paper. The longitudinal slot in the tube permits of perfect ventilation, and as the tubes are to be fixed with the slot downwards, no water can accumulate in them. The author admits that sometimes a bare wire may advantageously be drawn into the tube, and connected to it, in order to ensure a perfect and safe return. In comparing this system with several others usually employed, the author thinks that this system is much cheaper, and at the same time safer, assuming material of the best quality to be employed. He shows how the system can be applied to alternating monophase or polyphase current circuits, and to direct-current circuits. The use of the outer tube as a return simplifies the installation for electric lighting considerably, and is a safe system. *Discussion.*—**Levermann** said that a similar system was employed for the last ten years for the wiring of ships, in the cases where the body of the ship was used for the return. The system could advantageously

be employed for surface wiring. **Passavant** said that the system used in Stuttgart, where a bare middle wire is used for return and earthed, proved to be a success, but did not prove to be the same in Berlin, and the reason for it, he thought, lay in the difference of the nature of the mortar used. He also expects in this system that some corrosion of the tube may take place through electrolytic action. **C. L. Weber** thought that the limesalts of the mortar used might affect the insulation of the wire drawn through the conduit, and would like to know, therefore, whether any precautions have been taken to stop up the slot, in case the conduit has to be buried in the mortar? The **Author,** in reply, said that, by introducing a bare wire connected to the conduit, a safe return is ensured, and the tube acts as a very good protection, and as the insulated wire is usually drawn into the conduit after the mortar has had time to dry, there ought not to be any chance of moisture affecting the insulation. He has, however, devised means to prevent the entrance of mortar into the conduit. The paper is fully illustrated. L. G.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1449. *Power Transmission from St. Moritz to Lausanne on the Constant Current System.* **E. Bignami.** (Elettricità, Milan, 21. p. 164, March 16, 1902.)—The town of Lausanne acquired in 1898 a water-power of 10,000 to 15,000 h.p. on the Rodano at St. Moritz, 56 km. distant from Lausanne. A committee of five experts examined the tenders sent in for different systems, and selected the Thury system of constant continuous current at 23,000 volts. [See Abstract No. 1369 (1900).] The amount of the tender was 7,365,000 francs, while that of the three-phase system was 8,005,000 francs. The present installation provides for 5,000 h.p. The generating station contains five turbines by Escher-Wyss, each developing 1,000 h.p. at 300 r.p.m. under a head of 32 m. Each drives directly two dynamos, each of which gives 150 amperes at 2,300 volts. The five pairs of dynamos are connected in series and give 23,000 volts. There is no switchboard, but each set is provided with a cast-iron column on which are mounted a short-circuiting switch and an ammeter. A set is put into circuit by opening the turbine regulator till the dynamos give 150 amperes, when the short-circuiting switch is opened. The line, 54 kw. long, consists of two bare copper cables of 150 sq. mm. section, run on insulators. The Lausanne station at Pierre de Plan contains at present five motors of 400 h.p. each at 2,150 volts. Each motor has a small switchboard containing a voltmeter, an ammeter, and two short-circuiting switches, one automatic and the other operated by hand. Each motor also has an automatic regulator which shunts the field and shifts the brushes. Four of the motors drive three-phase generators supplying current at 300 volts for light and power in Lausanne. The fifth motor drives a continuous-current dynamo for the tramways, for which is installed a battery of accumulators and a booster. Plant for transmitting a further power of 5,000 h.p. will shortly be installed. G. H. B.

1450. *Rhyl Electricity Works.* (Elect. Engin. 29. pp. 438–443, March 28, 1902.)—This station is worked in connection with a dust destructor. There are two Babcock boilers, each giving 5,000 lbs. of steam per hour, and also two smaller ones, each evaporating 2,000 lbs. of water per hour; the latter can either be fired by coal or by means of the destructor gases. The destructors consist of four cells, each burning 10 tons a day. The small

boilers are placed immediately above the destructors, by which they are fired, and the others are placed at the end of the destructor house away from the engine-room but near the chimney. The generating plant includes three 150-kw. six-pole machines giving 300 amperes at 500 volts. There is also a balancer-booster set and a motor-driven tramway booster, which can raise the pressure 100 volts and has a capacity of 2½ kw. The accumulators consist of 274 cells, having a capacity of 25 kw. for nine hours. The crane lifts 4 tons, and has a span of 30 ft. 6 in. The distributors have a section of 0·125 sq. in., and the arc lamps are run ten in series on 500 volts. W. H. S.

1451. *Worksop Electricity Works.* (Elect. Rev. 50. pp. 288–290, Feb. 21, 1902.)—This direct-current station has two Lancashire boilers, 30 ft. by 8 ft., working at 125 lbs. per sq. in., and a chimney 150 ft. high and 5 ft. 6 in. in diameter. The engine-room is 56 ft. long and 28 ft. broad, with a height of 22 ft. to the bottom of the roof trusses. The generating plant includes one 150-kw. and two 100-kw. steam dynamos ; the steam consumption of the larger set on test was found to be 25·8 lbs. per kw.-hour, running condensing, the speed being 400 r.p.m. The balancer-booster set consists of four coupled machines, running at 1,200 r.p.m., each of the balancers having an output of 7 kw. The battery consists of 240 cells, having a rated capacity of 180 ampere-hours. W. H. S.

1452. *Nelson Electricity Works.* (Elect. Engin. 29. pp. 474–476, April 4, 1902.)—This continuous-current station contains two Lancashire boilers 30 ft. by 8 ft., an economiser of 192 tubes, three 200-kw. steam dynamos, compound wound, and a battery of 268 cells, giving 70 kw. for 10 hours. W. H. S.

1453. *Lighting of the Cornwall Canal, Canada.* (Elect. World and Engineer, 39. pp. 388–390, March 1, 1902.)—The generating station contains at present one 1,000-kw. three-phase alternator, running at 180 r.p.m., driven by water-power ; three similar units are to be further installed. The frequency is 60 cycles per second, and current is delivered at 2,200 volts. The pressure is transformed in a tower, which is built adjoining the power-house, to 11,000 volts for the power-transmission circuits, and also to 8,800 volts for use in connection with the 100-light circuits of series enclosed alternating arc lamps. At the present moment there are 250 arc lamps distributed along the canal, and power is used for operating canal gates, swinging bridges, &c., the pressure being again transformed to 500 volts for use with induction motors. It is expected that later a considerable amount of power will be utilised in connection with various enterprises which are situated on the banks of the canal. The tower contains on the ground-floor the high-tension switchboard, on the next floor the step-up transformers, and on the top floor the lightning arresters and the distributing cables. The water-wheels driving the large generator are arranged in two pairs with a fifth wheel used only in case of high backwater, the working head being 30 ft. W. H. S.

1454. *Power Transmission at Hartford, Conn.* **A. D. Adams.** (Elect. World and Engineer, 39. pp. 427–434, March 8, 1902.)—The system used for the electrical supply in Hartford, Conn., includes three generating plants, two driven by water and one by steam ; a substation of transformers and rotary converters in connection with the steam plant ; a separate substation with

transformers, rotary converters, and a large storage battery; and two transformer stations for street lighting with series arcs. The two water-power plants are located on the Farmington River, which rises among the Berkshire Hills of Western Massachusetts, more than 50 miles above the electrical power stations. The system permits of either the steam or the hydraulic plants, as may be required, carrying any desired portion of the total service load. The head of water available at the plant in East Granby, near the village Tariffville, which is over 11 miles distant from the steam plant, is 23 ft.; and that at the station in Windsor, at the point called Rainbow, about 105 miles from the steam plant, is 32 ft. The water-power station at Rainbow was put in operation during November, 1891, and the plant comprises two 600-kw., 500-volt, 60-cycle, two-phase Westinghouse generators, each belt-connected to a horizontal turbine wheel. This plant also contains four oil-cooled transformers, each of 300-kw. capacity, which are used for raising the pressure from the generators to 10,000 volts, and changing it in three-phase. The second hydraulic plant, which is situated 3 miles away from the first, has been in operation since November, 1899, and comprises two Westinghouse generators, each direct-coupled to a horizontal turbine wheel. Each of these generators has a capacity of 750 kw. at 500 volts, and the pressure is raised to 10,000 volts three-phase by transformers. The third plant is a steam plant in Hartford, containing one 600-kw. and one 400-kw. generator, each driven by belting from an independent steam engine. Besides these generators, this station contains a 1,500-kw. alternator direct-connected to a steam turbine, all of Westinghouse make. The turbine alternator runs at 1,200 r.p.m., and delivers energy at 2,400 volts and 60 cycles two-phase. The output of the system at full load is rated at 5,200 kw. The author points out that this steam turbine unit is the largest that has ever been built. The outfit weighs, including the generator, 175,000 lbs., and occupies a floor space of 33 ft. 3 in. long and 6 ft. 9 in. wide. The turbine is entirely automatic in all its functions, and requires very little attention. There are no rubbing surfaces, and consequently there is no necessity for internal lubrication, so that superheated steam and surface condensers may be employed to the greatest advantage. The steam-power station contains two rotary converters of 400-kw. capacity each, and four 375-kw., four 300-kw., and four 200-kw. transformers. At the battery substation on State Street, are two 250-kw. and one 300-kw. rotary converters, together with transformers of equivalent capacity, also a battery with 140 cells and a capacity of 17,000 ampere-hours. Two other substations, at opposite sides of the city, contain constant-current transformers which supply series circuits for alternating arcs. Each of the water-power plants is connected by an independent line with the steam-power station at Hartford. The 600, the 400, and 1,500-kw. generators of the steam plant deliver their energy at 2,400 volts to the same switchboard that receives the current from the transformers connected with the water-power plants. The author describes fully the system of transmission and distribution of the power generated at the different substations. Energy obtained from the water power is absorbed by the batteries during periods of small load, and the batteries discharge into the outside conductors of the three-wire system in the usual way. Where motors are supplied with alternating current, they are of the two-phase type, the two wires of each phase being brought to the motor. Arc and incandescent lamps are supplied from independent circuits representing each phase. Economy in the production of steam power at Hartford is sought by the use of the steam turbine above mentioned, of condensers with the engines, and of three large cooling

towers, in which the water from the condensers is subject to a mechanical draught of air while passing over layers of unglazed tiles. Fans for the production of this draught are driven by electric motors. The author gives statistics of the increase in output from the years 1892 to 1901, and also of the increase of income derived from the different uses of electricity for lighting and motive power. The Hartford system, in 1892, operated only 4,850 incandescent lamps, 476 public arc lamps, and 308 arc lamps used for commercial purposes; whereas at the end of 1901 there were connected 72,085 incandescent lamps, 643 public arc lamps, and 971 arc lamps used for commercial services. The number of motors connected in the year 1901 was 480—consuming 3,476 h.p. A very large motor load has been secured for the Hartford system, and the increase amounted to 945 per cent. in the 10 years mentioned. Since the second water-power station has been started, only a small fraction of the energy delivered has been generated from coal, except at those times of the year when the supply of water has been too small to meet the full demand. The output of the entire system in the year 1901 was 8,577,699 kw.-hours, and of this only 1,009,598 kw.-hours were developed by steam power. During five months of the year 1901, more than 98 per cent. of the total output was obtained from water power, yet, in February, the steam plant was required to develope 54·5 per cent. of the total energy. The author suggests that more attention should be given to the storage of the surplus water available, for use at the drier seasons of the year, reducing thereby the size of the steam plant, which is now almost idle during several months in the year. The total consumption of coal was 5,496 tons in the year 1892, and increased only to 6,306 tons in the year 1901. After a careful consideration of the different items which contributed to make the Hartford system a success, the conclusion arrived at is that water powers are to-day much the most important of the known factors by which the cost of electrical energy may be reduced. The paper is fully illustrated.

L. G.

1455. *Electric Generating Station at New Rochelle, N.Y.* (Amer. Electn. 14. pp. 103–110, March, 1902.)—The system is two-phase alternating, 60-cycle, 2,300 volts. At two substations, step-up transformers raise the pressure to 4,400 volts for street lighting distribution. The boiler- and engine-rooms run side by side; the former, 117 ft. 6 in. long by 45 ft. wide, contains at present 4 Stirling boilers, each rated at 250 h.p. and working up to 150 lbs. pressure per sq. in. The boilers are hand-fired from charging trucks which run on rails in front of the furnace doors. The feed-water pipes are in duplicate, and consist of 3-in. wrought-iron mains and 2½-in. brass branch pipes. The feed pumps are in the boiler-room, and are of the Duplex pattern. The steam-piping, of which plan and elevation are given, is in duplicate. It is extra heavy, and the flanges and fittings are of cast steel. Plan, elevation, and sectional views of the condenser piping and intake are given, as are also the pipe sizes. The engine-room is 117 ft. 6 in. long, by 54 ft. wide, and contains one 200-kw. Stanley alternator driven by belt from a horizontal compound tandem engine 13 in. and 23 in. by 17 in.; two horizontal cross-compound engines 18 in. and 36 in. by 42 in., each directly connected to a 500-kw. Westinghouse alternator of the revolving field type, running at 100 r.p.m.; two simple horizontal engines, each directly connected to a 25-kw. direct-current Westinghouse generator, running at 300 r.p.m. The large engines are designed for an economical load of 750 h.p. when supplied with steam at 160 lbs. pressure at the throttle valve, and exhausting into a con-

denser having a vacuum equal to 26 in. [The boiler pressure is given as 150 lbs. per sq. in.] The bearings are lined with Babbitt metal, and water-jacketed, and are provided with wedge adjustment. The governors are of the weighted Watt type driven by gearing, the spindle and rocking shaft working in ball bearings. The valves, which are of the pendant double ported Corliss type, are driven by separate eccentrics, and the cut-off can be carried to three-quarter stroke. The flywheel is 18 ft. in diameter, and weighs 70,000 lbs. It is of the segmental rim type. The switchboard permits of paralleling the machines. The front of the board contains only instruments and switch handles, all switches and live metal being behind. The bus-bars and shunt regulators are located in the basement, the handles of the latter being mounted in pillars standing in front of the board. The sizes of bus-bars, and other details, are given. Private lighting is carried out at 104 volts through transformers fixed on the street poles. F. B.

1456. *Middleton Electric Lighting and Tramways.* (Electrician, 48. pp. 969–973, April 11, 1902.)—This article deals with a small municipal electricity supply works, just opened at Middleton. The works will supply a small private lighting load in the town, nine public arc lamps to start with, and the Middleton Electric Traction Company's lines. The tramway lines were built by the British Electric Traction Company, and have a total length of 8½ miles of single track, with turn-outs, and are on the ordinary trolley system. The lines will possibly form an important link of intercommunication in the district, as the line to the south-west extends to the Manchester boundary, on the north it enters the borough of Rochdale, and to the east terminates at the boundary of the Oldham borough. There are 20 cars in all, 10 supplied by the Electric Railway and Tramway Carriage Works (Preston), and the other 10 by the Brush Electrical Engineering Company. All are of the double-truck type, and each is equipped with two 25-h.p. motors with single reduction gear. The lighting mains are on the 2 by 220 volts continuous-current three-wire system. The power-house contains three 250-kw. Belliss-Siemens sets, the dynamos being shunt-wound, with additional over-compounding coils for use on the traction circuits. Besides a switchboard for the lighting and one for traction, the equipment of the station includes a 50-kw. motor generator, so that at times of light load, both lighting and traction can be supplied from one main generator. The steam plant includes three Lancashire boilers, 30 ft. by 8 ft., and a 256-tube economiser. A Belliss surface-condensing plant is employed, capable of dealing with the exhaust steam from two of the engines. Circulating water is obtained from the river, and returned to it, no cooling tower or pond being necessary.
J. L. F. V.

1457. *Grand Rapids, Holland and Lake Michigan Railway.* **G. A. Damon** and **W. D. Ray.** (Street Rly. Rev. 20. pp. 127–137, March, 1902. Paper read before the Chicago Electrical Association, March 7, 1902.)—This line is 45 miles long, and runs for the most part through more or less open country. The power-house contains two 500-kw. three-phase alternators, and distribution is effected through rotary converters. The transmission wires are of aluminium, and carry current at 20,000 volts; the wires are placed 24 in. apart at the corners of an equilateral triangle. They are fixed to Provo glass insulators, weighing 6 lbs. each, with a diameter across the base of 7½ in. Glass insulators are supposed to be better than porcelain, and cost less. They do not require to be tested, and the life without deterioration is said to be longer. W. H. S.

1458. *High-tension Three-phase Railway at Wöllersdorf Arsenal.* **F. Golwig.** (Zeitschr. Elektrotechn., Wien, 20. pp. 133–138, March 16, and pp. 150–153, March 23, 1902.)—This is a short length of line connecting the arsenal with the steam railway line. Power is taken from an already existing station in the arsenal, which supplies current at 3,000 volts, and 42 cycles. The locomotive has a 50-h.p. motor, which drives one of the axles by means of toothed gearing. There is room for a second motor, in case it should later be found necessary. There are two overhead wires, the rails carrying the current in the third phase. There are two overhead collectors; only one is used at a time, and each corresponds to motion in a given direction. The collector is composed of two trolley-poles connected at the top by two copper roilers, which are insulated from one another. In the base of the trolley-pole there is a pneumatic cylinder, which can be operated by the driver, and causes the collector to be raised or lowered. The high-tension cables are supported on specially shaped porcelain insulators, spaced at distances of 4 in., and are, moreover, protected by iron tubing, which is connected with the roofing and framework of the truck. Sketches are given showing the construction of the locomotive, and a diagram gives the various pneumatic and electrical connections. The only parts in the driver's cabin which carry high-tension current are the distributing box and the main switch. Both are enclosed in cast-iron boxes, which are fastened by a special key; this key is so locked with the pneumatic apparatus that it can only be removed, and the boxes can consequently only be opened when both the overhead trolleys are lowered. The trolleys can only be raised again after the key has been replaced. The speed of the motor is 600 r.p.m., and the gearing is in the ratio of 6 to 1. The current in the rotor is controlled by a liquid rheostat, the rate at which the resistance is cut out depending on the operation of a dash-pot, worked by pneumatic pressure. The air compressor is worked by a 2-h.p, 100-volt motor, and gives a pressure of 4 atmospheres. The overhead conductors consist of two hard-drawn copper wires, 8 mm. in diameter, placed 87 cm. apart, and 6 m. above the level of the rails. The sections of the line which are in the terminal stations are normally switched free of current. The line, which is about 1 km. in length, has been constructed by Ganz on behalf of the Austrian Government. W. H. S.

1459. *Varese-Luino Electric Railway.* (Elettricità, Milan, 21. pp. 184–187, March 23, 1902.)—The present article deals principally with the hydraulic generating station. This is at Ferrara, and water is taken from the river Margorabbia near Ponte Natio. This river is liable to run very low in times of drought, and in consequence a reservoir of 500,000 c.m. has been formed by damming the Lago di Ghirla; an auxiliary reservoir near the intake of 10,000 c.m. capacity has also been made. A canal 300 m. long leads to a pipe-line 530 m. long; the pipes are 75 cm. in diameter, and from 5 to 8 mm. thick; the available head is 107 m. Three Pelton wheels by Riva, Monneret & Co., take each 340 litres per second, and develope 375 h.p. at 450 r.p.m. They drive directly three three-phase generators, giving each 250 kw. at 6,000 volts, and 45 $\sim$. The exciters are driven by belts from the generators. The turbine efficiency at full load is 78 per cent. The high-tension line is carried for the most part on the trolley-wire poles, and feeds 9 transformer stations. The trolley wires, fed from the low-tension side of the transformers, are two in number, of 8 mm. copper. The third conductor is formed by the rails. The railway is 25 km. in length, and runs on Vignole rails carried on oak sleepers. G. H. B.

1460. *The Vevey-Mont Pélérin Funicular Railway.* **H. Muraour.** (Elettricità, Milan, 21. p. 132, March 2, 1902.)—The length of the line is 1,577 m., and the height ascended 412 m. The gradients vary from 15 per cent. to 54 per cent., and the sharpest curve has a radius of 274 m. There are five stations on the route—Vevey, Corseaux, Beausile, Chardonne-Fougny, and Baumaroche—and these are arranged so that the ascending and descending cars stop simultaneously at two stations. The two cars are attached to a cable 1,600 m. long, passing over guide pulleys along the line, and over two pulleys in the station at the summit, one of which is the driving pulley. It is driven through gears and a belt by a motor of 80 h.p. Current is supplied from a station at a small distance. In this two gas engines of 25 h.p. each, working with Dowson gas, drive a dynamo giving current at 250 volts. A battery of accumulators of 400 ampere-hours' capacity is connected across the line, and is charged by the motor acting as a generator when either car is descending the gradient of 54 per cent. There are various safety devices at the station and on the cars. On the shaft of the driving pulleys is a band brake, which acts automatically if the speed is too high and cuts off the current. On the cars are two automatic brakes which grip the rails; a third brake is operated by hand, and, in case of the cable breaking, the axles in rotating close up the bearings by an endless screw gear. An overhead line enables the conductor to signal to the station to stop the motor. G. H. B.

1461. *Power Transmission at the Webster Coal-Mines.* **W. B. Clarke.** (Elect. World and Engineer, 39. pp. 541–543, March 29, 1902.)—The author gives a description of some early types of electrical mine locomotives, and then a description of a modern plant erected at the Webster Coal and Coke Company's mine at Ehrenfeld, Pa. The chief feature is 5,600-volt, 25-period, 5,600-volt three-phase transmission to a substation in the mine 9,000 ft. from the power-house, and conversion to a continuous current of 275 volts, which works the haulage locomotives which have 80-h.p. motors. The description is illustrated. Ll. B. A.

1462. *Electric Mining Installation in the Riebeck Mines.* **E. Beutom.** (Écl. Électr. 29. pp. 423–430, Dec. 21, 1901.)—This installation, executed by the A. E. G., of Berlin, has some novel features. The motive power consists of two Korting four-cylinder Korting gas engines of 125 h.p. each, actuated by gas distilled from coal, which is treated to a dry heat for the production of paraffin. This gas has a calorific power of 1,800 calories per cm. compared to 5,500 for oil gas. The transmission is at 3,000 volts and the motors work at 500 volts, transformers being used. The most novel feature is a hoist used for carrying workpeople into the pits. It is driven by a three-phase induction motor, and has a special regulating apparatus, with three brushes working on a series of contacts arranged like a commutator, by which it may be started, stopped, and reversed. A friction brake is provided, but in ordinary work the braking is effected by running the motor as a generator returning current to the line. The description is illustrated with photo blocks of the plant. Ll. B. A.

1463. *Power Transmission at the Thiederhall Mine.* **F. C. Perkins.** (Electricity, N.Y. 22. pp. 115–116, March 5, 1902.)—The author describes a plant installed by Siemens & Halske in this mine in Germany for working a winding engine or hoist on a level 300 m. below ground. The features are a 60-h.p. engine and dynamo running continuously and charging accumulators,

from which the two 150-h.p. motors (300 h.p. total) working the hoist are supplied. These can be worked in series or parallel giving a wide range of speeds. Lowering is done by running the motors as generators. Hand and automatic mechanical brakes are also in use. Ll. B. A.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

1464. *Calculations of Energy and Costs of Electric Tramway Systems.* **G. Guéroult.** (Écl. Électr. 29. pp. 351–356, Dec. 7, 1901, and 30. pp. 423–429, March 22, 1902.)—The first of this series of papers deals with the methods of calculating the hourly or daily amount of energy to be supplied to a car in terms of the weight, mean normal velocity, &c. Various cases considered are the actual starting, establishment, and maintenance of the normal speed, whether on the level or on ascending or descending grades or rounding curves. Equations are deduced by which the energy required in different cases may be calculated. The values of the different coefficients which enter into the equations are given, both the theoretical values and those deduced from actual experience. The final results are as follows for a mean speed of 3 m. per second: (1) The number of kilowatts to be generated at the station per car, empty or full, is found by multiplying its weight in either case by 0·0008; (2) the ratio of the number of kilowatt-hours corresponding to 1 kilowatt-car is obtained by multiplying the weight of the car considered by 0·0006; (3) the time occupied in accelerating from rest to full speed should be from 5 to 7 seconds, or longer for a higher mean speed.

In the second part of the paper the question of costs is considered, and a more rational method of evaluating the standing and running charges is described than the usual one of specifying them in terms of the kilowatt-car. The author divides the cost into two main heads: (1) Expenses proportional to the time of running and to the number of cars; (2) fixed charges, independent of the number of cars actually running, such as administration expenses, insurance, &c. Lastly, the question of tariff is considered, and that of the relative advantages of the trolley as against conduit and battery systems is briefly touched upon and decided in favour of the former. The comparative failure of the Paris tramways as paying concerns is attributed to the excessively low tariff combined with the great length of the runs. B. P. S.

1465. *Cost of Power for Electric Traction.* **A. D. Adams.** (Street Rly. Rev. 20. pp. 147–149, March, 1902.)—This article deals with the cost of power used on tramways in Massachusetts. The figures given relate to the cost per car-mile, and to the number of passengers carried per car-mile. The Boston Elevated Railway ran over 38 million car-miles in 1900, power cost them 1·36 cents per car-mile, and they carried 5·26 passengers per car-mile. Similar figures are given for 43 other railways in the State, the highest cost of power being on the Worcester and Webster line, which ran 240,000 car-miles at a cost for power of 5·7 cents per car-mile; the lowest cost was on the Newton and Boston line with 535,000 car-miles, run at a cost for power of 1·31 cents per car-mile. The figures do not, however, show that any definite relation can be traced between the size of a line and the cost of power, though in general the author considers that the larger systems more frequently adopt methods of construction and operation that lead to high efficiency. W. H. S.

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

1466. *Electric High-Speed Railways.* **L. v. Reymond-Schiller.** (Zeitschr. Elektrotechn., Wien, 20. pp. 109–112, March 2, 1902.)—This is the conclusion of a series of articles. [See Abstract No. 1255 (1902).] Experiments on two electrical street railways at Budapest are quoted which furnish data for the calculation of the possible speed with different gradients, and it is concluded that a broad track is essential for high-speed railways with ordinary gradients. A train run on a gauge of 4·5 m., having a locomotive weight of 120 tons, and with two coaches of 240 tons provided with seats for 200 passengers, would require for a speed of 250 km. per hour as much as 20,000 h.p. This apparently Utopian figure the author thinks ought to be seriously considered in view of the facility of electrical transmission of energy by high-pressure alternating currents. W. W. H. G.

1467. *Electric Street Railways in Chicago.* **E. B. Ellicott.** (West. Electn. 30. pp. 141–142, March 1, 1902.)—This is a report by the city electrician to the authorities, who instructed him to consider the "physical condition" of the important street railways in Chicago. He reports that the Union Traction Company has 600 miles of track; but the use of a small trolley wire and an inadequate system of connecting the feeders to the trolley are undesirable features. The safe carrying capacity of the trolley wire is 140 amperes; feeders are connected to it every 200 ft. in congested districts, and every 800 ft. in outlying districts. But in congested parts the overhead wire has not a sufficient capacity to furnish the amount of current required to work the cars at a proper speed. On a certain section of the line which appears to be near the centre of the town, the transmission losses are estimated at 33 per cent., but a large percentage of this is probably lost in the return circuits, which are said to be insufficient and composed of poorly bonded rails. The motors are geared for a maximum speed of 15 miles per hour, but during the busy hours the maximum speed is about 11 miles an hour, and in the congested district the power is insufficient to propel a loaded car at a greater speed than 6 miles an hour. The Chicago City Railway Company has 200 miles of track, and uses a large-sized trolley wire. But they, too, have a district which is seriously congested, and where the cars are only worked at 4 miles an hour. On this section during busy hours the transmission losses are estimated at 50 per cent. The steam plant of this company is said to be very much out of date, and with the use of better machinery the author estimates that a saving of 33 per cent. could be effected in the coal consumption. He also considers that the times occupied in getting the cars up to full speed and in stopping them are unnecessarily long, and though this may contribute to the consumption of a smaller amount of power, this probably contributes to accentuating the congested state of the traffic. W. H. S.

1468. *Report on the Accident on the Liverpool Overhead Railway.* (Engineer, 93. p. 319, March 28, 1902.)—An abstract of the report by the Board of Trade is here given. The evidence showed that the insulation of a cable connected to the motor at the end of the train had become defective; an arc was started, the rush of current opening the circuit breaker, and stopping the train. The driver, however, repeatedly tried to start the train by closing the circuit breaker, with the result that the end of the train was eventually set on fire. The rear motor should have been disconnected and the journey continued with one motor only, as is always done if one of the motors breaks down. The report concludes by pointing out that flexible cables covered with rubber or other

combustible material should not be used on the main current conductors of electric trains. These conductors should be rigid, and might be bare or enamelled, or protected by incombustible ferules in iron pipes. Flexibility should be restricted to necessary points, and should be provided by pinned hinge and knuckle joints, shunted by bare flexible links of wire gauze, or by some other sound mechanical mode of construction. Little or no wood should be used in the construction of electric locomotives, and the resistances and controlled switches should be placed, if possible, in front of and outside the driver's cab. W. H. S.

1469. *Surface-Contact Systems.* **W. Kingsland.** (Inst. Elect. Engin., Journ. 31. pp. 879–880; Discussion, pp. 880–883, April, 1902.) (Abstract.)—The author described the various systems, and drew more particular attention to his own [see Abstract No. 942 (1900)]. He said that, instead of the star-wheel switch, which he had originally proposed, he now intended to employ one lever arm only, which could be pressed down by the striker, and returned automatically so as to be ready for the next stroke.

Discussion.—**V. Bornand** said he had superintended the laying of one of the lines in Paris on the Claret-Vuilleumier system, in which one switch operates a number of studs. It is working successfully. The switch can be placed under the pavement or road; the insulation used is mica, and the accumulation of moisture or gases is prevented by ample ventilation. If vulcanite, indiarubber, or bitumen enter into the composition of the insulating material, any sparking produces decomposition, and explosions have occurred owing to these gases being confined in air-tight switchboxes. **J. C. Vaudrey** pointed out that on the Claret-Vuilleumier system, the concentration of coils and magnets and cables in a large cast-iron box about 2 ft. in diameter in the street seemed likely to be unsatisfactory and would probably break down owing to moisture. The **Author,** in reply, said this system had been working since 1896. He proposed to put his own stud in a concrete block, and it would be almost impossible for a pool to form round it, as was alleged to happen in Paris. A large number of horses had been killed in Paris, but it was believed that they had all been killed by the Diatto system [see Abstract No. 1992 (1899)], which employed a mercury contact, and a plunger, which was drawn up in a very small switchbox, there being, therefore, a great liability to heating. There would be no sparking whatever in his own switchbox, providing the switches were operating properly and one came on before the other came off. W. H. S.

1470. *Permanent Way.* (Railroad Gazette, 34. pp. 203–205, March 21, and pp. 220–223, with Discussion, March 28, 1902. Extracts from the Report of the Committee of the American Railway Engineering and Maintenance-of-Way Association.)—*Track.*—The Committee in its report considers the following subdivisions of its subject: Maintenance of line; maintenance of surface; maintenance of gauge; inspection of track and track tools. They are all discussed in detail. In considering the subject of the super-elevation of the outer rail in curves, the Committee recommend for ordinary practice, as giving the essentially correct theoretical elevations, the formula $E = GV^2/32{\cdot}16R$, where E = elevation in feet, G = standard gauge, V = velocity in feet, R = radius of curve in feet. Since the elevation required is a function of and depends upon the train speed, speed is the first element to be determined. It is not unsafe to run over a curve at a higher speed than that for which it is elevated; a train may safely run 10 miles per hour over a curve

which has no elevation, or 60 miles per hour over a curve elevated for 50 miles per hour; but the practice is not recommended. The Committee advocated originally for ordinary practice a maximum elevation of 7 in., although on the subject being thoroughly discussed a difference in elevation of 8 in. was finally recommended. The above formula gives results expressed in the following table :—

VELOCITY IN MILES PER HOUR.

DEG.	10	15	20	25	30	35	40	45	50	55	60	65	70	DEG.
1	1/16	1/8	1/4	3/8	5/8	13/16	1	1 3/8	1 5/8	2	2 3/8	2 3/4	3 1/4	1
2	1/8	5/16	1/2	7/8	1 5/16	1 5/8	2 1/8	2 5/8	3 1/4	4	4 3/4	5 1/2	6 1/2	2
3	1/4	1/2	3/4	1 1/4	1 3/4	2 3/8	3 1/8	4	4 7/8	6	7 1/8	8 3/8	...	3
4	1/4	5/8	1 1/16	1 5/8	2 3/8	3 1/4	4 1/4	5 3/8	6 5/8	8	...	...	...	4
5	3/8	3/4	1 5/16	2 1/16	3	4	5 1/4	6 5/8	8 1/4	...	...	...	...	5
6	7/16	1 5/16	1 5/8	2 1/2	3 9/16	4 7/8	6 5/16	8	...	...	...	...	...	6
7	1/2	1 1/16	1 7/8	2 7/8	4 1/8	5 5/8	7 3/8	...	...	...	...	...	...	7
8	9/16	1 1/4	2 1/8	3 5/16	4 3/4	6 1/2	8 3/8	...	...	...	...	...	...	8
9	5/8	1 3/8	2 3/8	3 3/4	5 3/8	7 1/4	...	...	...	...	...	...	...	9
10	1 1/16	1 1/2	2 5/8	4 1/8	5 5/16	8 1/16	...	...	...	...	...	...	...	10
11	3/4	1 11/16	2 7/8	4 1/2	6 1/2	8 7/8	...	...	...	...	...	...	...	11
12	7/8	1 7/8	3 1/8	5	7 1/8	...	...	...	...	...	...	...	...	12
13	7/8	2	3 7/16	5 3/8	7 3/4	...	...	...	...	...	...	...	...	13
14	1	2 1/8	3 1/16	5 3/4	8 3/8	...	...	...	...	...	...	...	...	14
15	1 1/16	2 5/16	3 5/16	6 1/4	8 7/8	...	...	...	...	...	...	...	...	15
16	1 1/8	2 7/16	4 1/4	6 5/8	...	...	...	...	...	...	...	...	...	16
17	1 1/4	2 5/8	4 1/2	7	...	...	...	...	...	...	...	...	...	17
18	1 1/4	2 3/4	4 3/4	7 1/8	...	...	...	...	...	...	...	...	...	18
19	1 3/8	2 7/8	5	7 7/8	...	...	...	...	...	...	...	...	...	19
20	1 3/8	3 1/16	5 1/4	8 1/4	...	...	...	...	...	...	...	...	...	20

Finally the Committee, although recognising a departure from theoretically correct principles, advised that the lower rail should not be depressed. *Ballasting.*—The Committee state that the materials which best fulfil the requirements for ballasting are broken stone, gravel, coarse sand, burnt clay, partially disintegrated rock, slag, and cinders, and various products resulting from the separation of ores. Recommendations for depth of ballast give a minimum of 8 in., with an average of 12 in. Minimum dimensions for cross-sections are assigned to rock ballast and maximum to light materials such as coarse sand in which the sleepers or ties should be buried. Burnt clay formed a leading topic in the ensuing discussion, the trend of opinion being that it formed a good ballast when pure clay, free from sand or vegetable matter, was obtainable. One ton of coal produced from 4 to 4½ yards of good ballast. *Supply and Life of Cross Ties.*—American railroads have only recently commenced to treat their ties. In recommending trials, on a small scale, of that various timber preserving processes the Committee draws special attention to the cheaper varieties of petroleum which although not an antiseptic itself may possibly be rendered so by the addition of other substances. *Rails.*—This Committee confined their deliberations to the subjects of rail sections and specifications. It was urged that much better rails than are at present being made could be turned out from the steel now in use, provided it received the proper treatment in rolling. The bad effects arise from the use of a too high finishing temperature, which simply changes the form of the mass without changing its structure. A standard specification for steel rails was brought forward and recommended for adoption, the chief feature of which is the drop test. This is to be made on a piece of rail not more than 6 ft. long, the test piece being taken from the top of the ingot and placed on solid supports 3 ft. apart. The following impact tests

to be made with a drop test machine having a tup of 2,000 lbs. weight, with an anvil block of at least 20,000 lbs. :—

Weight of rail per yard	45–55	55–65	65–75	75–85	85–100 lbs.
Height of drop	15	16	17	18	19 feet.

If any rail breaks when subjected to this test, two additional tests to be made with other rails from the same blow of steel, and if either of these fail all the rails of the blow to be rejected. The report also mentions that the Pennsylvania Railroad advocates higher carbon percentages than have been hitherto used, as the drop test shows that rails finished at a lower temperature give a greater deflection than those finished at the higher. C. E. A.

1471. *Concrete-steel Bridges for Inter-urban Railways.* **D. B. Lutin.** (Street Rly. Rev. 20. pp. 137–139, March, 1902.)—The author considers the various systems of reinforced concrete in vogue in the United States. Although concrete has been used extensively in recent years for bridge abutments, arches, and culverts, the use of concrete-steel results in a more reliable and efficient structure. Furthermore, as concrete is a more economical material than steel for transmitting compressive stresses, so steel is more efficient for transmitting tension ; a combination of the two materials in such structures as flat floor arches or girders where the steel is embedded in the concrete is very effective. In the Melan system I beams curved to follow the central axis of the ring are bedded in the concrete at intervals of 3 or 4 ft., while in the Thacker system pairs of bars are used, one being placed close to the inner edge of the arch rib and the other close to the outer edge, both being spaced laterally at intervals of 3 or 4 ft. In the author's system, which consists of a single series of steel rod or bar reinforcement, the principle that steel is not economical in compression is taken advantage of, to retain only those parts of the rods that are in tension. The amount of material saved by the use of a steel reinforcement is 60 per cent. C. E. A.

1472. *Re-rolling Worn-out Rails.* (Railroad Gazette, 34. pp. 174–176, March 14, 1902.)—The process described is carried out under the patents granted to E. W. McKenna. The charge for re-rolling rails is from 5 to 6 dollars a ton. The re-rolled rails have the same height as the original rails, but a smaller section. The worn-out rails are first re-ground, if necessary, and then heated in specially designed reverberatory furnaces, each of which takes an average charge of 20 rails, 30 ft. long. Some drawings are given showing the sections of a rail, which was re-rolled four times. The process appears to have been previously described in some detail in the Railroad Gazette, August 2 and 16, 1895. W. H. S.

1473. *Electric Car Equipments.* **A. W. Wigram.** (Inst. Elect. Engin., Journ. 31. pp. 668–671, March, 1902. Abstract of paper read before the Newcastle Section, Dec. 16, 1901.)—The ordinary hand brake leaves little to be desired, though the application of power by a direct pull tends to bend the platform. Some method should be adopted by which the strain is, as far as possible, confined to the truck. The best form of springs for the brake blocks is a helical one, about 8 in. long, having an extension of 1 in. for 70 lbs., and $\frac{3}{8}$ in. adjusting bolts. Slipper brakes and electromagnetic brakes are recommended : but rheostatic brakes are undesirable, as they throw too much strain on the motors and resistances. Sanding gear is often unsatisfactory. It

should be arranged so as to be worked by the left foot of the driver. Sand is often necessary in very dry weather; so much so that a car running at 8 or 10 miles an hour will slide on for 100 or even 150 yards if the emergency brake is applied without sand on a very dry track, the wheels being almost locked. The best form of trolley wheel is one having a wide groove, with a shallow depression in it equal to the diameter of the trolley wire and half its depth. Graphite bushings should be frequently oiled; in this way their life is increased by about 40 per cent. Trolley standards should be securely fastened to the roof of the car; if there is a wide side reach and the trolley wire is at all slack, the fastenings are apt to be loosened unless precautions have been taken to resist a side strain. W. H. S.

1474. *Brakes and Safeguards for Electric Tramways.* **Seefehlner.** (Zeitschr. Elektrotechn., Wien, 20. pp. 161–168, March 30, 1902.)—The author reviews critically the different protecting systems now in use in various countries to prevent accidents from electric tramcars in motion. After considering the mechanical construction of most of the safeguards used, the author thinks that the problem is not as yet satisfactorily solved, and points out that only in conjunction with properly constructed brakes can good results be obtained. A detailed description of most of the brakes used is given, and the importance of the electric brake in all its forms of construction and application is emphasised. The paper is fully illustrated, showing the safeguards and brakes now in use. L. G.

1475. *Electromagnetic Tramway Brakes.* (Schweizerische Blätter für Elektrotechnik, 7. pp. 35–37, March 8, and pp. 44–46, March 22, 1902.)—This is an illustrated description of the various forms of electromagnetic brake manufactured by Siemens & Halske. They include different kinds of friction-plate brakes, and also a solenoidal brake, the plunger of which is connected to the levers, which are ordinarily operated by the hand-brake. W. H. S.

1476. *Electrolysis by Earth Returns.* **R. Ulbricht.** (Elektrotechn. Zeitschr. 23. pp. 212–215, March 13, 1902.)—The author considers mathematically the values the stray currents derived from the working of electric railways, having the rails as returns, can attain, and their influence upon any metallic pipes running either parallel or transversely to the line of direction of the rails. The author takes a few typical cases for his calculations, and, from the formulæ obtained, makes some general deductions, which tend to explain the actions taking place in practice. For instance, the electrolytic action is increased, and the depth at which the metal is affected becomes greater when the current acts upon a smaller metallic surface; the total loss of metal is, however, larger if the action of the current is distributed over larger surfaces. Badly insulated pipes show the electrolytic effect more markedly on those parts where the insulation is worst. In order to avoid this, the pipes have to be either very heavily coated with an insulating material, which is an expensive and cumbersome method, or preferably, as suggested by the author, the electric conductivity of the pipe may be interrupted by the intercalation of insulating pieces which act as joints, sockets, &c., the construction of which require some further consideration. The paper is quite mathematical in all its bearings, and the conclusions derived are of a general character, so as to indicate the actions which take place when metallic pipes are in close proximity to, or further from, the rails, and also the means by which these effects can be diminished. L. G.

1477. *Herman's Automatic Electric Semaphore.* (Railroad Gazette, 34. pp. 178–179, March 14, 1902.)—This instrument is designed to work three-position signals such as those referred to in Abstract No. 996 (1901); it is, however, suitable for any other types of signal. The rod through which the semaphore arm is operated is connected to a sector which is capable of oscillating freely about the main shaft of the instrument, and the parts are so arranged that, when the sector is free, the semaphore arm moves to its "stop" position. The sector is provided on its periphery with a series of notches corresponding to the several positions in which it is to be secured, these notches co-acting with a locking bolt actuated by a high-resistance electromagnet through a compound toggle lever. The sector is moved by means of a main clutch wheel mounted concentrically thereto and driven by an electric motor through a train of spur gearing. The said clutch-wheel has a series of V-shaped recesses for engaging with the bolt of an electromagnetic clutching device, which is of similar construction to the locking device above mentioned, and is mounted on the sector, the electromagnet in this case being of low resistance and coupled in series with the motor. The current is controlled by switch contacts mounted on the moving parts. The current required is 1·6 amperes at 12 volts. One of these instruments has been making 500 movements per day for seven months without a failure, the consumption of current per day being 6·6 ampere-hours. C. K. F.

ELECTRIC LAMPS AND LIGHTING.

1478. *Discussion on Improved Apparatus for Arc-light Photometry.* (Amer. Inst. Elect. Engin., Trans. 19. pp. 313–320, March, 1902.)—Referring to the paper by **C. P. Matthews** [see Abstract No. 623 (1902)], **C. H. Sharp** wished to know whether the author could not make use of a reduced copy of the apparatus described, for the determination of the mean spherical candle-power of the incandescent lamp by means of one measurement; and also whether he could not do away with the rotating sectored disk, replacing it by a simpler means of cutting down the intensity of the light. **C. P. Matthews** in reply said that it is quite possible to cut down the light effectively by means of the smoked glass, as he has done so with success. A miniature device for incandescent light photometry has also been used by him, but he is bound to spin the lamp in order to obtain the mean effect. **C. J. Spencer** asked what difference exists between the distribution of candle-power in alternating-current and direct-current lamps. In answer to this, the author referred to the published report of the National Electric Light Association, which dealt elaborately with that point [see Abstract No. 1001 (1901)]. **G. T. Hanchett** said that, instead of the flat pieces of glass used by the author in order to make the sigma equations as nearly as possible represent the integrals, he would suggest making a mirror which should be the frustrum of a cone instead of the frustrum of a pyramid. To that suggestion the author pointed out the difficulties which would be encountered, and also the objection that, as soon as one departs from the plane mirror, one gets a focussing mirror, and what is measured is, in that case, not the intensity, but the flux of the light. The number of plane mirrors used cannot be increased above a certain size without increasing the diameter of the ring, which is a serious objection. **C. H. Sharp** pointed out another difficulty connected with **Hanchett's** proposition, viz., that of smoking the glass to the requirements of the apparatus. **C. P. Steinmetz**

preferred to obviate, by the use of a simpler method, the necessity of having the screen smoked exactly to a certain intensity of absorption, which he considers a very delicate operation ; and he asked whether the mirrors could not be replaced by white surfaces to measure the illumination as a secondary source of light, that is, instead of reflecting mirrors, to have a circle of white disks, and measure the total illumination coming from these disks? **C. P. Matthews** said that, although the suggestions were feasible in part, the method would be more complicated than the original one suggested by him, and gave reasons for this. **C. H. Sharp** concurred in the author's remarks. To the questions asked by **Hanchett** about the mean diameter of the frustrum of the pyramid forming the mirrors, and to **Woodward's** question whether any attempts have been made to obtain a self-registering record, and whether the selenium cell could not be used for it, the **Author** replied that the diameter is about 6 ft. ; and as for the selenium cell, attempts have been made, but the selenium cell and photographic effects, and all other effects, differ from the physiological effect, and therefore he thought that there will never be anything else than the human eye to fix those values. **A. E. Kennelly** (communicated) emphasised the advantages to be derived from such apparatus in measuring the mean spherical candle-power in one operation ; and pointed out that, although in the comparison of light sources, the spherical candle-power is the only reliable basis, at the same time it seemed doubtful whether it would be advisable to rate lamps commercially in terms of spherical candle-power, because it would diminish incandescent lamp ratings about 15 per cent., and arc-lamp ratings about 50 per cent. It would seem preferable to refer spherical candle-power measurements to the amount of light emitted. Since a unit spherical candle-power represents 4π lumens of light emitted, a spherical Hefner means 12,566 Hefner lumens emitted, a spherical British candle-power 12,566 British lumens, and so on. Similarly, an arc lamp of 1,200 maximum British candle-power, instead of being rated as of, say, 600 mean British spherical candle-power, would be a lamp of 7,540 British lumens, and if consuming 450 watts, its light efficiency would be 1,675 British lumens per watt. L. G.

1479. *The Heany Enclosed Arc Lamp.* **E. Trier.** (Elect. World and Engineer, 39. pp. 487–488, March 8, 1902.)—This lamp, which is the invention of J. A. Heany, of Philadelphia, presents a number of novel features, viz. :— The frame consists of two plates in the form of equilateral triangles, having the angles joined by rods on which slides the regulating solenoid by means of eyes fitted with set-screws so that it can be moved up or down to adjust the length of the arc. The solenoid is wound with bare wire insulated with asbestos-cord between adjoining convolutions and sheets of asbestos between successive layers, so as to reduce the liability of burning out to a minimum. The upper carbon is secured at its upper end to a cap connected by a flexible conductor to the supply conductor, and slides in a brass tube forming a central member for the lamp frame. The core of the regulating solenoid is formed by the two halves of a longitudinally slit tube, which halves slide over the central frame-tube inside the regulating solenoid, and are hinged together at their lower ends. The clutch-jaws form downward extensions of these halves, and extend through apertures in the central frame-tube to engage with the upper carbon. When the solenoid is de-energised, these jaws fall on to a fixed cone and are thus separated ; when, however, the solenoid is energised, the halves of the core-tube repel each other by reason of their being of like polarity, and cause the jaws to grip the carbon before

lifting it in striking the arc. The magnetic field is strengthened by placing a shell of soft iron around the solenoid. The combined clutch and core is connected to a dash-pot through the pin of one of the hinges above mentioned. C. K. F.

1480. *The Regina Enclosed Arc Lamp.* **B. Donath.** (Elektrotechn. Zeitschr. 23. pp. 220–221, March 13, 1902.)—In this paper further description and tests are given of this lamp, of which some particulars have already been given in Abstract No. 1011 (1902). These lamps differ from the previous types of enclosed arc lamp in that the carbons are not guided through stuffing-boxes, but are shut off from the external air by the inner globe and the body of the lamp. The supply of oxygen is regulated by special means, not described. Calling the actinic power obtained from a Regina lamp, of 220 volts and 3 amperes, unity; with a similar lamp of 110 volts and 6 amperes, it was 1/2·6; with an open lamp of 55 volts and 12 amperes, 1/4·4. The light from a window (January, 12 o'clock, blue sky) was 1/5·4; and that from a window (January, 12 o'clock, clouded sky) 1/9·1. An open arc lamp of 55 volts and 6 amperes gave 1/9·0. The actinometer was placed 40 cm. away from the lamps provided with white globes. At this distance, the 220 volt and 3 amperes lamps corresponded in its actinic action to that of the light of midday in July, so that it is extremely useful for photographic purposes. Barium platinum cyanide is lighted up intensely. The spectrum shows three main groups of lines, of which the first is intensely blue, the second clear violet, and the third dark violet. The discharge in the enclosed space approximates to that in a slightly exhausted Geissler tube. C. K. F.

1481. *Crawford Voelker Incandescent Lamp.* **T. C. Crawford** and others. (Elect. Rev. 49. pp. 1038–1039, Dec. 20, 1901, and 50. p. 13, Jan. 3, 1902.)—Correspondence, in which attention is drawn to the fact that the published results of recent tests on this lamp [see Abstract No. 624 (1902)], are of little value, because the c.p. and voltage are not stated. W. R. C.

REFERENCES.

1482. *High-Tension Electric Power Transmission.* **G. H. Gibson.** (Eng. Mag. 3. pp. 75–89, April, 1902.)

1483. *Electricity in Greece.* **F. W. Jackson.** (Cassier, 21. pp. 443–455, April, 1902.)

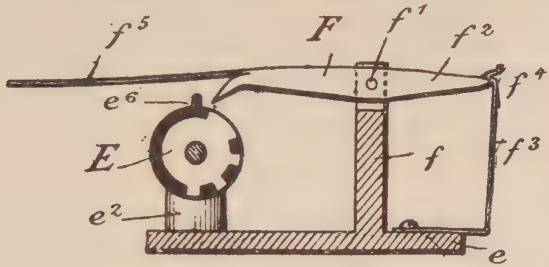
1484. *Montmorency Falls Power Plant.* **F. C. Perkins.** (Elect. Engin. 29. pp. 510–511, April 11, 1902.)—The article contains a general description of the station, which supplies power for the lighting and tramways of Quebec. [See also Abstract No. 285 (1901).] W. H. S.

1485. *Power and Lighting Plant of the Chicago University.* (Eng. Record, 45. pp. 245–248, March 15, 1902.)

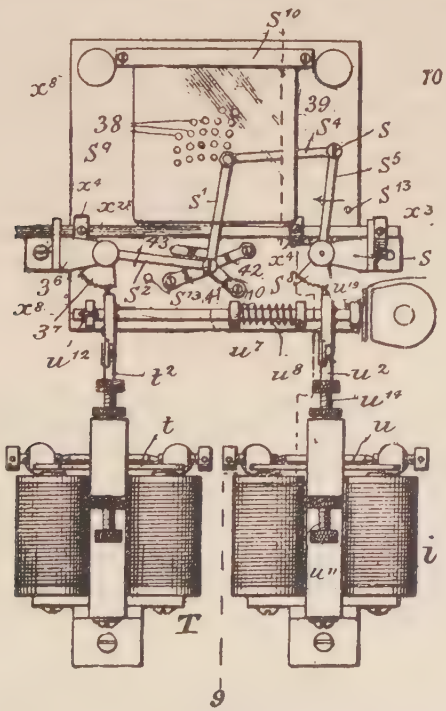
1486. *Chilled Cast-iron Car Wheels.* (Railroad Gazette, 34. p. 227, March 28, 1902. Extracts from an address delivered before the Engineering Students of Pardue University by Mr. C. H. Vannier, of the Griffin Wheel Company, Chicago.)—A descriptive account is given of the origin, development, and modern processes of manufacture of chilled cast-iron car wheels. C. E. A.

TELEGRAPHY AND TELEPHONY.

1487. *Gilmore Automatic Printing Telegraph System.* (West. Electn. 30. pp. 189–191, March 22, 1902.)—The sending typewriter is so arranged that when a key is depressed it moves a contact lever appropriated to the



particular letter so that it comes into contact with metal surfaces representing dots and dashes of the Morse code. These surfaces are mounted on insulating fibre, and occupy regular spaces along the signal shaft. The



first diagram shows the arrangement for the letter "B." The lever is held up until the key is depressed by the catch at one end. After one revolution of the shaft, the little fibre projection raises the lever again to its position of

rest. The shaft does not revolve continuously, although the electric motor which actuates it is constantly running, but the depression of any one of the key levers throws in a clutch between the motor and the signal shaft, thereby causing the latter to revolve. The shaft releases itself from the clutch at the end of each revolution, and all parts are left in their normal condition. At the receiving end, the long and short impulses operate two separate relays. This is accomplished by a system of retardation winding and condensers. As shown in the second diagram, two magnets in the relay circuits operate escapements on a right-angle link movement composed of four light forked arms of steel. The middle joint of these arms carries a series of spring-pressed contacts which, when brought into position, press against a "group" of contact points, of which there are 40 for letters and numerals. It is through these contacts that the printing mechanism is actuated. The electrical and mechanical means of obtaining the desired movements are fully described in the article. E. O. W.

1488. *Device for Synchronising Telegraph Motors.* **W. Duane.** (Elect. Rev. N.Y. 40. pp. 357–358, March 15, 1902.)—In multiplex, printing, and picture telegraphy, it is sometimes necessary to have two drums rotating synchronously at each of two stations. The device described enables this to be done through the two wires or through the wire and earth return connecting the two stations. The circuit is used for synchronising purposes only during a small fraction of the period of a revolution of the drum, and the power transmitted over the line is only that required to work a sensitive relay. It consists of a motor suspended with the axis of its armature vertical, and resting on a steel plate. When rotating at the proper speed an arm swings out by centrifugal force and a platinum plate its brought into contact with the platinum-tip of a thumb-screw, which short-circuits the armature and prevents further increase of speed. The speed remains constant within half a per cent. A picture is shown of a machine for multiplex telegraphy with 18 segments in the commutator in addition to that for the synchronising device. It has been successfully tried in the laboratory of Colorado University over eighteen distinct circuits in the neighbourhood operated simultaneously. A. R.

REFERENCES.

1489. *Telephone Exchange of the National Telephone Company at Kensington.* (Electrician, 48. pp. 250–254, Dec. 6; and pp. 292–294, Dec. 13, 1901.)—Description of exchange system, central battery switchboards, &c., at the Kensington Exchange of the National Telephone Company. J. E. K.

1490. *Telephone Exchange of the Glasgow Corporation.* (Electrician, 48. pp. 333–337, Dec. 20; and pp. 374–378, Dec. 27, 1901.)—Description of exchange system, switchboards, &c., of the Glasgow Corporation. J. E. K.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

AUGUST 1902.

GENERAL PHYSICS.

1491. *Elastic Properties of Helical Springs.* **J. W. Miller, Jr.** (Phys. Rev. 14. pp. 129–148, March, 1902.)—This is both a mathematical and experimental paper; brass and steel springs being examined. The static theory of helical springs of Thomson and Tait (Nat. Phil., 1867) is experimentally verified. To a high order of approximation, the force required to elongate a helical spring varies directly as the product of the elongation of the spring and the square of the secant of its slope. When such springs are elongated by an axial pull, with no applied torsional couple, they undergo a twist about the axis of the helix; this twist increases as the pull increases, up to a maximum, and thereafter decreases continuously with increasing pull. The relations of elongation to applied force enable the modulus of twist and the modulus of rigidity of the wire of the spring to be found. The elongations of maximum twist and zero twist enable the ratio, modulus of twist : modulus of bending, to be found. Combinations of these enable the modulus of bending, Young's modulus, and Poisson's ratio to be readily derived.

A. D.

1492. *Flow of Solids.* **J. R. Benton.** (Amer. Journ. Sci. 13. pp. 207–210, March, 1902.)—The flow of solids is studied by using masses of Wood's fusible alloy, each cast on a framework of soft fuse-wire, melted together at the joints. After deformation, the masses were jacketed with plaster-of-Paris, and the Wood's alloy then melted. The distorted form of the framework was then examined. As compression proceeds, wires at right angles to the plates of the testing-machine take the form of curves with two points of inflexion, and there is a shearing of the whole mass parallel to the plates of the machine.

A. D.

1493. *Plasticity of Clay.* **P. Rohland.** (Zeitschr. Anorg. Chem. 31. 1. pp. 158–160, 1902.)—After discussing the various views current with regard to the cause of plasticity of clay and similar substances, the author points out that the capability of taking the plastic state is exhibited by such bodies as form colloidal solutions with water. The fact that neither positive nor negative

catalysers will affect the phenomena tends to show that plasticity cannot be due to a hydration reaction. Capillary affinity may possibly account for the more than mechanical combination of water with those substances. A. G.

1494. *Cohesion of Liquids.* **Leduc** and **Sacerdote.** (Comptes Rendus, 134. pp. 589–591, March 10, 1902.)—This is measured by two experimental methods, first by the ascent in a capillary tube in vacuum, secondly by a barometer tube. The capillary tube was 0·007 cm. in diameter, and the water rose in it to 43 cm. Since the vapour-tension of water is 19 cm., and since the column preserved without rupture exactly the same height at all degrees of exhaustion, the cohesion is more than the pressure due to 24 cm. of water. Similar experiments with the barometer tube for water and mercury are described. J. W. P.

1495. *The Pressure of Vibrations.* **Rayleigh.** (Phil. Mag. 3. pp. 338–346, March, 1902.)—The author gives several examples to show how the energy of the vibration of a vibrating system may be drawn off and converted into other forms of work. The first example is as follows: A string is attached at its upper end to a vertical axis, and a ring slides over the axis, including the upper part of the string, the lower part being free. To the lower end is attached a pendulum, which is set swinging. That, by its oscillation, tends to force the ring upwards, any work done in raising it being, of course, at the expense of the vibration energy. If E_1 be the energy when the length of the pendulum is unity it is found that E, the energy of vibration when the length is l, is $E_1/\sqrt{l}$, showing that by raising the ring to an infinite distance the whole energy of vibrations would be exhausted. The next example is that of a stretched string vibrating transversely in a plane, the vibrations being confined between a fixed and a movable ring. This gives analogous results, except that we have here E_1/l instead of $E_1/\sqrt{l}$.

A third example is the vibration of air in a cylinder, Boyles' law being assumed. This also gives analogous results. The author then passes to a more general treatment, showing how Lagrange's equations lead to analogous results, if integrated over a long time T so as to make the integrated term $\frac{1}{T}\int dt \frac{d}{dt}\frac{dt}{d\dot{q}}$ disappear. The Lagrangian method is applied to the first example of the pendulum, and to more general problems, including Reynolds' theory of the group velocity, and Boltzmann's theory on the application of Carnot's cycle to radiation enclosed within movable reflecting walls. He raises the question whether an analogue of the second law of Thermodynamics can be found in the general theory of the pressure of vibrations, but does not give, apparently, a final answer. S. H. B.

1496. *On the Extension of Lagrange's Theorem.* **P. Duhem.** (Comptes Rendus, 134. pp. 580–581, March 10, and pp. 686–688, March 24, 1902.)—Certain difficulties which occur in the study of viscous liquids disappear if we assume an adhesion between the liquid and a solid, according to the hypothesis of von Helmholtz and Pietrowski, or, according to the present writer, if the condition of adherence be assimilated to the introduction of new connections. The pressure is then not necessarily normal to the adhering surface—a result which the writer proposes shortly to discuss in a work on the theory of friction. Other difficulties are introduced by the extension of Lagrange's theorem to viscous liquids. The writer refers to a theorem announced by Hadamard, that Lagrange's theorem may be extended to viscous

liquids, at least so long as the motion is analytic. And this theory he claims to have in effect discovered himself. But he has proved (he says) also that no wave can exist in a viscous incompressible liquid of uniform constant temperature. Therefore Lagrange's theorem is applicable at all points of such a liquid, except those which at a given instant have played the part of singular points, or have been on a singular line.

The author mentions several physicists as having applied Lagrange's theorem to viscous liquids. Such a liquid is supposed in the problem to be initially at rest in contact with solid bodies, and to be gradually set in motion. Considering this problem, he arrives at the conclusion "That Lagrange's theorem extended to viscous liquids, is incompatible with the conditions which such liquids have to satisfy on the surfaces of solids." He then puts the question how the difficulty is to be removed. Boussinesq has suggested the following method, to assume namely, "That when a viscous liquid moves from rest at an initial instant ($t=0$), the integrals of the equations of motion which are analytical for positive values of t are in general not analytical for $t=0$." The author is, however, not satisfied with this explanation, and suggests that there may be an imperfection in the theory of viscous liquids to which the difficulty is due. [See also Abstracts Nos. 1283 and 1284 (1902).] S. H. B.

1497. *Transversal Oscillations of an Elastic Sphere.* **E. Kohl.** (Ann. d. Physik, 7. 3. pp. 516–553, March, 1902.)—This writer investigates an expression for the amplitudes of a spherical wave of torsion, supposed to be expressible in harmonics, advancing through an elastic medium. The oscillations on any wave surface are in parallel circles. He notes that the velocity c, of propagation will, in case of a spherical wave, be a function of the distance r from the centre. It is constant only for a plane wave. The disturbances on the vibrating elastic sphere from which the waves originate are then—

$$u=0, \qquad v=\frac{z}{\sqrt{y^2+z^2}}\,\mathrm{U}\,\sin 2\pi p\Big(t-\int_0^r\frac{dr}{c}\Big),$$

$$w=-\frac{y}{\sqrt{y^2+z^2}}\,\mathrm{U}\,\sin 2\pi p\Big(t-\int_0^r\frac{dr}{c}\Big).$$

From these expressions, solutions are found by the aid of Lamé's integrals, and in terms of the two functions—

$$\Pi_n'(r)=\sqrt{\frac{c_n(r)}{c_0}}\,\sin 2\pi p\int_0^r\frac{dr}{c_n(r)}, \qquad \Pi_n''(r)=\sqrt{\frac{c_n(r)}{c_0}}\,\cos 2\pi p\int_0^r\frac{dr}{c_n(r)},$$

in which c_0 is the value of c when r is the radius of the vibrating sphere, and $c_n(r)$ satisfies the differential equation—

$$\frac{dc_n}{dr^3}+4\left\{\left(\frac{2\pi p}{c_0}\right)^2-\frac{n\,.\,\overline{n+1}}{r^2}\right\}\frac{dc_n}{dr}+4\frac{n\,.\,\overline{n+1}}{r^3}c_n=0,$$

n being the order of the harmonic. It is then proved that the two Π functions are identical with the R functions of Laerisch. Applying the principle of energy, it is found that if at distance r_1 the amplitude is A, then at r_2 it is $\frac{\mathrm{A}}{r_2}\sqrt{c_n(r_2)}$. It is explained that the author's results give only the conditions under which the displacements are conformable to the equations of elasticity, and not the manner in which they are created. In the immediate neighbour-

hood of the vibrating sphere there will be, in fact, two systems of oscillation, the first of which, for great values of r, leads to waves advancing with velocity approximately constant, and amplitude varying nearly as $1/r^2$. The second system is attributed to a slipping of the medium over the vibrating sphere, forming as it were an image thereof. The influence on these phenomena of the ratio of the wave-length to the radius of the vibrating sphere is pointed out.

The writer then applies his formulæ to certain numerical calculations, in order to give an idea of the actual form of the wave.

In section 6 is investigated the periods of vibrations for $n = 1$, as determining the nature of the emitted spectrum, and the damping of the oscillations. The latter investigation leads to the conclusion that the assumption of very small density for ether makes the constants of damping far too small. Finally, a section is devoted to the consideration of longitudinal oscillations, and the difference between their results and those of transversal oscillations. S. H. B.

1498. *Oscillations of a Disc Immersed in a Viscous Liquid.* **C. Zakrzewski.** (Acad. Sci. Cracovie, Bull. 4. pp. 235–242, April, 1902.)—The writer assumes Maxwell's theory of viscosity, and its recent developments by Natanson [see Abstract No. 811 (1902)]. The subject has also been treated by O. E. Meyer and Schmidt. The disc is a plane one, suspended by a vertical elastic thread, and oscillates in its own plane in the liquid. It is assumed (1) that no forces act except that of viscosity; (2) that the liquid is incompressible, and the hydrostatic pressure within the liquid constant; (3) that the motion is extremely slow, so that the products of the velocities and their derivatives may be neglected. Under these circumstances, if ψ denote the angular velocity at any point in the liquid, u, v the component velocities of a molecule of the liquid parallel to x and y (the suspending thread being taken for axis of z and the plane of the disc for that of xy), we have $u = -\psi y$, $v = \psi x$, and u and v satisfy the equations—

$$\frac{\partial^2 u}{\partial t^2} + \frac{1}{T}\frac{\partial u}{\partial t} - A^2\frac{\partial^2 u}{\partial z^2} = 0,$$

$$\frac{\partial^2 v}{\partial t^2} + \frac{1}{T}\frac{\partial v}{\partial t} - A^2\frac{\partial^2 v}{\partial z^2} = 0,$$

from which is derived "the telegraphist's equation"—

$$\frac{\partial^2 \psi}{\partial t^2} + \frac{1}{T}\frac{\partial \psi}{\partial t} - A^2\frac{\partial^2 \psi}{\partial z^2} = 0. \quad \text{.....(1)}$$

In these equations T denotes the "time of relaxation" for the liquid, and A the ratio of the rigidity to the density. These results are taken from Natanson's paper referred to above. The writer then takes from Natanson the expressions for the tensions within the liquid, and calculates the forces exerted by the liquid on the disc, with especial reference to the case in which one side only of the disc is wetted (Schmidt's experiment). For a particular solution of the equation (1) he takes $\psi = \varepsilon^{-mt}\{C\sin(\nu z) + D\cos(\nu z)\}$, where m and ν satisfy the relation $m^4 - m^2/T = -\nu^2 A^2$. The classic equations of hydrodynamics are deducible from this by making $T = 0$, and $A^2T = \eta/\rho$, ξ and η being the displacements of a particle of the liquid parallel to x and y. Dealing with this integral, he obtains the fundamental equation of Meyer and Schmidt. S. H. B.

1499. *Stability of the Configuration of Equilibrium of a Liquid in a Capillary Tube.* **G. Morera.** (Accad. Lincei, Atti, 11. pp. 223–228, March 16, 1902.) —Laplace, in his Supplement to the theory of capillary action, states that when the figure of a capillary tube diminishes by very small gradations the successive states of equilibrium are alternately stable and unstable. Matthieu in his theory of capillarity objects to Laplace's reasoning as vague and inconclusive, but according to the present author his own reasoning is equally wanting in precision.

We are to suppose a tube of rotation about a vertical axis. In his notation r is the distance from the axis or any point on the free surface, ρ the radius of the curve in which the free surface cuts the internal surface of the tube, ϕ the angle (supposed obtuse) between the free surface and the internal surface of the tube, i the inclination to the vertical of that surface, and z is the height above a fixed plane. He constructs the curve, called the c curve, $\rho z = -a^2\cos(\phi + i)$. Then he denotes by σ' the area of the surface of the liquid which is in contact with the tube, and by σ'' the area of the free surface; θ and η are the known constants of capillarity; P is the potential of the capillary forces, dS an element of volume of the liquid at height z, and the density of the liquid is taken as unity. It is found that—

$$P = g\int z d\mathrm{S} + \frac{\theta_1}{2}\sigma'' - \left(\eta_1 - \frac{\theta_1}{2}\right)\sigma',$$

the integral being taken over the whole volume of the liquid. This leads to the equation—

$$\partial P = g\pi\int_z^{z+\partial z} r(r-\rho)z dz,$$

in which r is the distance from the axis, and ρ is the radius of the curve in which the free surface cuts the internal surface of the tube. The test of stability is the sign of $r - \rho$. Hence is derived the conclusion that the stable configurations are those in which, in passing along the c curve upwards, we pass through the meridian section of the tube from outside to inside. The unstable configurations are those in which the passage is from inside to outside. S. H. B.

1500. *Theory of Errors of Judgment and the Personal Equation.* **K. Pearson.** (Roy. Soc., Phil. Trans. 198. pp. 235–299, March 14, 1902.)—Two variables x and y may be defined to be correlated, when there exists a third variable, or more than one such, of which x and y are both functions. Professor Pearson divides correlation into two kinds, logically distinct, one of which he brands as spurious. The reasons are given in a former memoir (Roy. Soc. Proc. vol. 60). In the present paper he gives an example of spurious correlation, [which, however, seems itself to be in need of explanation]. A star is observed to pass from A to B through an intermediate point C. Two observers measure the time from C to B in terms [so it is said] of the *known time* "a" from A to B. And this is done for many stars at different times and the results are found to be correlated. Now if a be really known, and therefore invariable, it may be the unit of time, and to say that both sets of observations are in terms of a is no more than to say that both are expressed in terms of the same unit. Then why and how are they correlated? If on the other hand a, though supposed to be constant is really variable, as if the time were measured by a clock whose rate of going is variable, why is the

correlation spurious? The answer to that question is to be found in the above-mentioned memoir. A definition is given of "personal error" and "personal equation." Personal error may be absolute or relative. If ξ be the true value of the thing observed, x_1 and x_2, the values given by two observers, then $\xi - x_1$, $\xi - x_2$ are the *absolute*, and $x_1 - x_2$ the *relative* personal errors. They are denoted in this paper by p_{01}, p_{02}, and p_{12} respectively. In many cases the relative personal error is all that can be determined. In addition to his personal error, the merit of an observer depends also on his "stability," or the inverse of that quantity σ whose square is the mean square of the errors in many observations. For two observers the author uses σ_{01}, σ_{02} and σ_{12}. He discusses the current theory of errors, according to which there is a normal, or canonical form of curve, to which it is the duty of any series of observations to conform, namely, that indicated by the exponential $\epsilon^{-h\Sigma x^2}$, where the index is the sum of the squares of the errors or deviations from the mean. And evidently the assertion is involved that $\epsilon^{-hx^2}dx$ is the chance that any given one of the errors shall lie between x and $x + dx$. This law of distribution depends for its existence wholly on the assumption of the mutual independence of the x's, *i.e.*, on the assumption that the chance for any one error lying between x and $x + dx$ is independent of all the other x's. The law does not prove the independence, as has been fondly imagined, but merely expresses the independence already assumed as a fundamental axiom. Assuming the normal law to hold, but not otherwise, the author finds for three observers the following simple relations, $2\sigma_{01}^2 = \sigma_1^2{}_2 + \sigma_1^2{}_3 - \sigma_2^2{}_3$, &c. From these, if true, we could determine the absolute from the relative stabilities, which has been a difficulty. For this reason a series of experiments was devised to test the normal law, with the result that the above formulæ were found not to hold.

In section (3) and again in (9) the author doubts the legitimacy of the assumption of independence, even where the x's are the errors of judgment made by apparently independent obervers. And this is perhaps the only one of all the many cases to which the law $\epsilon^{-h\Sigma x^2}$ has been applied, in which there is anything to be said for it. In all other cases its use is justified, not by evidence, nor by *a priori* probability, but only by the elequence of the results to which it leads us. The connection to be applied for correlation depends upon the products xx'. For instance, the correlation in absolute judgment between two observers is given by the formula—

$$r_{12} = \frac{\Sigma(p_{01} - \overline{\xi - x_1})(p_{02} - \overline{\xi - x_2})}{n\sigma_{01}\sigma_{02}}.$$

The simplest way of introducing the connection would be to make the index a quadratic function of $x_1 \ldots x_n$, and not merely the sum of squares, but Professor Pearson does not go into that question in the present paper. It would involve the undoing of the work which mathematicians have so laboriously done in reducing the quadratic function to a sum of squares. Several experiments were made, in order to measure the intensity of correlation for absolute and relative errors. It is sufficient to describe the first experiment. There were formed 500 groups, each group containing three equal lines, in all three similar series each of 500 lines, but the lines in the same series not equal to each other. To each of three observers was assigned a series, and he marked, according to his judgment, the point of bisection of each line. The results were then compared with the points of bisection actually measured, and the personal errors and correlations tabulated.

The same series were also taken in groups, and the results of the grouped compared with the ungrouped observations, with reference to a paper by Sheppard (London Math. Soc., Proc. p. 368, &c.).

The author then (sec. 7) considers the constancy of the personal equation. And in sec. 9 he again discusses the question of the applicability of the orthodox theory, and the experiments organised to test it. The question he puts is whether the general nature of the distribution of observed quantities is capable of being described by the orthodox curve of errors on the assumption that the observed quantities are taken at random from the "population" of errors which the observers would make if they were to go on with their experiments for an infinite time, or as he calls it a "random sampling."

The result obtained is that, even in this the most favourable possible case for the assumption of independence, that is, for the orthodox law, the supposed accordance, actual or "practical," of a series of observations with the orthodox curve which some writers have persuaded themselves that they see, has no existence. The author summarises his conclusions as follows :—(1) That the personal equation, while tending to a constant value, is subject to fluctuations far exceeding those of random sampling. (2) Observations are "sympathetic," so that there may be correlation of judgments between two observers supposed to be independent. (3) In addition to psychological correlation, there is a spurious correlation arising (he says) when two sets of observations are referred to a common standard. (4) Errors of judgment, absolute or relative, are generally far from being in accordance with the orthodox theory.

And he concludes further (*a*) That the correlation of judgment is a necessary factor in one appreciation of the personal equation. (*b*) That we should attempt to find, not only the personal equations of two observers, but also the variations and correlation of their judgments. (*c*) That the existence of such correlation vitiates the ordinary theory of the credibility of testimony. (*d*) That great care should be used in applying the orthodox theory, until it be shown that, within the fluctuations of random sampling, the observations really follow the orthodox law. We have no right to assume *a priori* that they do so. S. H. B.

1501. *Earthquake Waves.* **W. Schlüter.** (Phys. Zeitschr. 3. pp. 238–242, March 1, 1902. Abstract from Gerland's Beiträgen zur Geophysik, vol. 5, Parts 2 and 3.)—Earthquake diagrams show at first the "preliminary tremors," and afterwards the "large waves" of longer period. The question arises whether the latter are similar to waves on water, involving an oscillation of the normal to the earth's surface about the direction of gravity, or whether they are due to horizontal oscillation of the earth's crust. The author has endeavoured to answer this question by using a seismograph whose centroid is in the axis of rotation, and which therefore is susceptible only to waves of the former class. He calls the instrument a "clinograph," and gives its theory as well as a full description. It detects an angular deviation of 0·02 second. In experiments carried out in the autumn of 1899, when numerous earthquakes were shown by the horizontal pendulum, the clinograph gave no deflection. It follows that neither the "preliminary tremors" nor the "large waves" are due to oscillation of the normal to the earth's surface. Such oscillation either does not exist or is too small to be observed with the modern seismograph. W. S.

1502. *Baxendell Self-recording Anemoscope.* (Feilden, 6. pp. 245–248, March, 1902.)—A description is given of the J. Baxendell instrument for separate, continuous records of the wind direction in use at the Marshside Station of the Fernley Observatory, Southport. A very light vane, with two blades of aluminium, 30 in. long, joined under an acute angle, is mounted on a tubular steel spindle, 30 ft. above the roof; the vane is conveniently fixed 5 ft. below the vanes of the Dines anemometer. The weight of the vane and spindle is carried on ball bearings. The chart drum rotates with the spindle. A Dines anemometer pen, carried on a vertical rack, drives by its weight a clock; attached to this rack, underneath the holder for the Curtis pen, is a short brass arm, which supports a bevelled metal ring, encircling the chart, in front; the ring, which fits loosely over the chart, sinks a little at the back, and keeps the overlapping end of the paper tight. H. B.

1503. *New Barometric System for the United States, Canada, and the West Indies.* **F. H. Bigelow.** (Monthly Weather Rev. 30. pp. 13–19, Jan., 1902.)—With January 1, 1902, a new system for the reduction of barometric pressures has been put in operation in the United States, Canada, and the West Indies. As the meteorological stations are at different elevations up to 7,000 ft., and the surface temperatures of a single chart may range between $-40°$ and $+60°$, these reduction problems are very important, and this is the sixth attempt made since 1871 to deal with them. The author has perfected Ferrel's system, which was in use for one year in 1886–87. The new planes of reference are the sea-level; the 3,500 ft. plane, the average height of the Rocky Mountains' stations and also of the cumulus base in the eastern states; and the 10,000 ft. plane, already applied to some extent, which is just in the middle of the most rapid horizontal cyclonic and anti-cyclonic currents. Eighteen geographical points, intersections of the 50th, 45th, 40th and 35th parallels of latitude, and the 90th, 100th, 110th, and 120th meridians, are adopted as centres of reduction. The vertical temperature gradient in free air is assumed to be 0·30° F. per 100 ft.; within the Rocky Mountains' plateau it is on average 0·195° F. It follows that, using the smaller gradient up to the plateau, larger values than 0·3° must be employed from the surface to the 10,000 ft. plane if the average gradient is to be 0·3° F. There would, therefore, at the surface of the plateau, be something like an abrupt change in the gradient, which he terms gradient refraction. Charts of normal monthly and annual pressures, temperatures, vapour tensions, and relative humidities have been prepared for the three planes of reference; further charts of gradients of temperature in latitude, longitude, and altitude. The number of stations on the sea-level plane is 265, of stations on the upper planes 175. To facilitate the calculations, the author, in conjunction with Heiskell and Hawkins, has computed logarithmic reduction tables in English measures, for intervals of 100 ft. up to 10,000 ft. and of 10° F. from $-40°$ up to $+100°$. H. B.

1504. *Hertzian Waves in the Sun.* **C. Nordmann.** (Comptes Rendus, 134. pp. 591–594, March 10, 1902.)—The existence of such rays in the sun will explain the aurora borealis and the perturbations of terrestrial magnetism. The periods of the auroræ agree with those of the sunspots. If the sunspots indicate the emission of Hertzian waves, these, striking the rarefied atmosphere, act in exactly the same way as they do when they fall upon a Geissler tube, *i.e.*, produce kathodic phenomena of the well-known kind. The author opposes Arrhenius's explanation of the auroræ by streams of

negatively charged particles. The action of the rays upon the upper layers of the atmosphere affect the atmospheric currents of electricity, to which are attributed the phenomena of terrestrial magnetism. Lastly, it is pointed out that sudden variations of the sunspots, brilliant auroræ, and magnetic storms, are all concurring phenomena. The explanation by Hertzian waves would unite and explain all. J. W. P.

1505. *Motion of the Nebula of Orion.* **H. C. Vogel.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 14. pp. 259–266, March 6, 1902.)—Some photographs of the spectrum of this nebula were taken at the end of last and the beginning of this year with the spectrograph No. IV. of the Potsdam Observatory, and, from the displacement of the $H\gamma$ line, the velocity of the nebula was found to be + 17·4 km. per second. This dispersion of the instrument is such that 0·25 mm. corresponds to a wave-length difference of 0·424 $\mu\mu$, and the above velocity is a mean of values obtained by two independent measurements of five plates. The region of the nebula was the same as that previously examined by Keeler, who obtained a mean velocity of + 17 7 km., namely the well-known trapezium. Some other plates, however, of other portions of the nebula showed a different displacement of the $H\gamma$ line, in particular, one plate containing the spectrum of the nebula close by the star Bond 685. The $H\gamma$ line in this case was distorted, one portion being more displaced than the rest. Evidence is thus furnished of considerable internal motions in the nebula. [See also Abstract No. 1303 (1902).] E. C. C. B.

1506. *Some Results obtained with the Bruce Spectrograph.* **W. S. Adams.** (Astrophys. Journ. 15. pp. 214–217, April, 1902.)—*The variable velocity of o Persei in the line of sight.*—Five plates taken between February 19 and April 3 give a velocity varying from — 117 km. per sec. to + 134 km. per sec. The spectrum is of the Orion type, but the Helium lines are somewhat weak, while the magnesium line λ 4481 is hardly visible. *The variable velocity of δ Libræ in the line of sight.*—Four plates show a variation in the velocity between + 36 km. per sec. and — 123 km. per sec. The magnesium line λ 4481 is broad and of moderate strength. The measures of velocity are uncertain by several kilometres. *The radial velocity of Sirius.*—Ten plates gave as a mean value — 6·87 km. per sec. for the epoch of 1902 06. From this result and that of — 15·6 km. obtained by Vogel and Scheinen for the epoch of 1890·09, a computation of the parallax was made, and found to give 0″·21, which is rather lower than Gill's heliometric measurement of 0″·31. *The wave-length of the magnesium line* λ 4481.—On account of the broad and diffuse nature of this line as observed in the laboratory, it was thought advisable to obtain its wave-length from stellar spectra. After the effects of radial velocity were eliminated, ten plates of Sirius, three of γ Geminorum, and two of θ Leonis gave as a mean value 4481·400, the extremes being 4481·414 and 4481·382. This value was used in the determination of the radial velocities of *o* Persei and δ Libræ given above. [See also Abstract No. 829 (1902).] E. C. C. B.

REFERENCE.

1507. *New Micrometers.* **W. Weicholdt.** (Zeitschr. Instrumentenk., Beib. 6. pp. 53–55, March 15, 1902.)—These are made with wheel and lever motions, and the length is given by the reading of a pointer on a circular scale, the instruments reading directly to from 0·02 mm. to ·0001 mm. G. E. A.

LIGHT.

1508. *Velocity of Light.* **A. A. Michelson.** (Phil. Mag. 3. pp. 330–337, March, 1902.)—The author discusses the accuracy of the accepted values of the velocity of light, the ratio of the two electrical units, and the velocity of Hertzian waves, and considers that new determinations are necessary. A new method is suggested which is free from most of the drawbacks pointed out by Cornu [see Abstract No. 283 (1902)] and is virtually a combination of the Foucault and Fizeau methods. The light from a slit passes through a lightly silvered glass plate and a lens and falls on the upper half of a revolving mirror. It is reflected to a grating which reflects to the lower half of the mirror, and the beam passes by way of a lens to the distant mirror. By this arrangement the author hopes that the velocity may be determined to within 5 km. or less. G. E. A.

1509. *Images formed by a Parabolic Mirror.* **H. C. Plummer.** (Royal Astron. Soc., Monthly Notices, 62. pp. 352–369, March, 1902.)—The above forms a first paper containing the geometrical theory of the subject, and including criticisms of previous papers by Tennant, Schaeberle, Crockett, and the author. It results that it is impossible to effectively overcome the aberration of a parabolic mirror by any of the usual devices, and "the more or less kite-shaped images are unavoidable in the case of a reflector as ordinarily adapted for photographic use." Parabolic mirrors for a definite purpose may be designed by aid of the equations given. G. E. A.

1510. *Refractive Power of Mixtures.* **A. Leduc.** (Comptes Rendus, 134. pp. 645-646, March 17, 1902.)—It is known that this is conserved in mixtures in which there is no combination. Damien found that this was the case in mixtures of glycerine and water; the author now finds the same with alcohol and water. A. D.

1511. *Mechanical Equivalent of Light.* **K. Ångström.** (Phys. Zeitschr. 3. pp. 257–259, March 15, 1902.)—The total radiation of a Hefner lamp is determined by means of the author's compensation pyrheliometer (Wied. Ann., 1899), the value found being 0·00129 gr. cal./min. at 1 m. distance. To measure the visible radiation, a spectrum is produced, and the invisible rays are cut off. The visible part is brought through a cylindrical lens and a water cell to a photometer, and balanced against the direct light from a similar source. On replacing the photometer by a bolometer or thermophile, the ratio L/Q of the energies in the two beams is found to be 0·90 per cent. $\pm$ 0·04 per cent. Hence the "mechanical equivalent" of unit intensity of illumination is 8·1 erg./sec. per sq. cm. at 1 m. distance. The value L/Q = 5·5 per cent. was found for an acetylene lamp, and is about half that found by Stewart and Hoxie. Recalculation from Stewart's numbers corrects an error and gives L/Q a value between 5 per cent. and 6 per cent. G. E. A.

1512. *Intensity of Radiation in connection with the Earth's Motion.* **H. A. Lorentz.** (Konink. Akad. Wetensch. Amsterdam, Versl. 10. pp. 804–809, March 29, 1902.)—It has been suggested by Fizeau that, provided the ether does not

share the earth's motion, there should exist a notable difference in the intensity of radiation emitted by a source of light or heat placed on the surface of the earth, according to its direction coinciding with, or being opposite to, the direction of the velocity v of the earth, a vibration starting from L having to traverse a path $lc/(c-v)$ or $lc/(c+v)$ respectively, where l is the velocity of light. Now the author shows, by an approximate calculation, that the current theories of electrical and optical phenomena in moving bodies may account for the negative results given by any experiments intended to verify Fizeau's suggestion. In fact, in the expression developed for the energy of radiation, the velocity of the earth is found not to occur.

A. G.

1513. *Table Photometer and Standard Pentane Burner.* **F. Clowes.** (Soc. Chem. Ind., Journ. 21. pp. 313–315 ; Discussion, pp. 315–316, March 15, 1902.)—The author describes the newly-adopted apparatus used in the London Gas-testing stations, and shows the different improvements made, in order to insure more accurate testing of the illuminating value of the gas used in London. The standard lamp is a 10-candle-power one, and is arranged to burn air which has been carburetted by admixture with the vapour of pentane, and advantage is taken of the high specific gravity of pentane vapour (2, 5. compared with air) to make the supply to the flame automatic. The mixture of air and pentane vapour is burnt from a steatite argand ring, and the circular flame is fed inside with air which has been heated by passing between two long, concentric, chimneys placed immediately over the flame. The pentane which is used in the carburettor is prepared from light American petroleum, by purifying the fraction which distills over at 45°. The new lamp furnishes a more convenient, and a much less variable, standard than that yielded by candles. The paper is fully illustrated, showing the lamp in section and front view. The table photometer differs in two important respects from the ordinary bar photometer, when it is used for testing the illuminating power of coal-gas. The observer is seated on one side of the semi-transparent screen, and both sources of light are placed at fixed distances upon the other side. Further, the equating of the light from the different sources is effected by the adjustment of the gas supply to the test burner, instead of by altering the distance of either source of light from the screen. The distances between the screen and the pentane lamp and gas-burner are carefully adjusted by means of rods of standard lengths, and the relative positions of the burners are also similarly adjusted. The apparatus is also made portable. A diagram shows the arrangements for fixing the apparatus.

L. G.

1514. *Reversal of Photographic Image.* **M. I. Wilbert.** (Frank. Inst., Journ. 153. pp. 231–235, March, 1902.)—Experiments are described on long exposure and development in diffused daylight, with production of positives instead of negatives. The result is as if the long exposure had produced a faintly visible negative image, and this image protected the film under it from further action of light ; and as if the developer was therefore able to act more energetically upon the portions of the film previously less exposed.

A. D.

1515. *Magnetic Rotatory Polarisation in Absorption Bands.* **O. M. Corbino.** (N. Cimento, 3. pp. 121–132, Feb., 1902.)—The author's conclusion that the

rotation within a sodium band was in the same direction as outside it was challenged by Professor Voigt. The author has again experimented, and come to the same conclusion, opposed to theory though this be. The amount of rotation is small, but is approximately proportional to the strength of the field. [See also Abstracts Nos. 36 and 465 (1902).] A. D.

1516. *Selective Absorption as a Function of Wave-length.* **G. E. Hale.** (Astrophys. Journ. 15. pp. 227–228, April, 1902.)—In photographs, published in a previous paper [see Abstract No. 1536 (1902)], of the spark spectrum of iron in water, it was to be seen that the reversals first appeared at the more refrangible end of the spectrum, and as the conditions became more favourable, lines of greater wave-length became reversed. Similar results were obtained with titanium, magnesium, cadmium, copper, nickel, cobalt, lead, and aluminium. Selective absorption thus appears to resemble general absorption. This is interesting in view of Campbell's discovery that in the spectra of certain stars the ultra-violet lines of hydrogen are dark, while those of greater wave-length are bright. Frost has suggested an explanation of such spectra on the assumption that the law of selective absorption resembles that of general absorption, as also has Kayser in more detail. [See Abstract No. 649 (1902).] E. C. C. B.

1517. *The Band-Spectrum of Nitrogen.* **C. Cuthbertson.** (Phil. Mag. 3. pp. 348–353, March, 1902.)—Deslandres has shown that the bright lines of the second group of this spectrum ($\lambda = 5{,}000$ to $\lambda = 2{,}820$) conform to a law that the interval between one line and the next are approximately in arithmetical progression. The author shows that the first group ($\lambda = 6{,}622$ to $\lambda = 5{,}000$) obey somewhat the same law. The oscillation frequencies of the heads of the bands fall into thirteen series, some of which contain only two numbers. The difference in frequency between the first two numbers of the first series is 1,531; this difference between the first two numbers falls in arithmetical progression down the series to the thirteenth, where it is 1,129. Similarly, also, the differences between the members of each series fall in the same arithmetical progression. By this arrangement certain anomalies are accounted for. It is noteworthy that the arithmetical progression of the above is the same as that of Deslandres for the second group, and begins where that left off. E. C. C. B.

1518. *A Personal Equation in Measuring Photographic Spectra.* **B. Hasselberg.** (Astrophys. Journ. 15. pp. 208–213, April, 1902.)—In measuring wavelengths by comparison and interpolation between lines in the solar spectrum, very distinct differences were observed between the values obtained when readings were made from red to violet, and when from violet to red, the difference being greatest, about 0·033 tenth meter, when a spectrum of the arc was compared with that of the sun. The effect is a physiological one depending on a tendency to misjudge the centres of bright and dark lines in juxtaposition on a plate. An effect of the same magnitude, but in the opposite sense, has been noted by Reese. E. C. C. B.

1519. *Standard for Röntgen Rays.* **G. Contremoulins.** (Comptes Rendus, 134. pp. 649–651, March 17, 1902.)—Apparatus is described, analogous to a photometer, for comparing the light on the fluorescent screen with light derived from an acetylene flame, and also for testing the penetrative power of the rays by means of adjusting the position of a wedge of metal interposed, while the above comparison is being carried out. A. D.

1520. *Induced Radio-activity.* **A. Sella.** (Accad. Lincei, Atti, 11. p. 57, Jan. 19, and pp. 242–245, March 16, 1902.)—A zinc or aluminium spiral surrounds a tinfoil-lined axial cylinder of cardboard pierced by many needles thrust through it ; the spiral and the core are respectively connected with the terminals of an induction electrical machine ; then, whether the spiral be positive or negative, it is strongly radio-active. Tesla's transformer does not produce nearly the same effect as the electrostatic machine.

A metallic body becomes radio-active when points are made to face it, and points and body are connected to the poles of an electrostatic machine, with a condenser in derivation, for, say, an hour. The distance between the points and the metallic body is made such that there is an effluvium but no sparks. The metallic body becomes radio-active, even when its charge is positive, provided that the air is fresh air, not the stale air of a room closed for some hours, but not even in fresh air unless there be plenty of room round the metallic body ; but all metals act equally. If the metallic body be connected to the machine and the points to earth, after some time, the metallic surface becomes altered and shows Kundt's figures. If the experiment be carried out in stale air (box closed for sixteen hours), charged with the emanations from thorium oxide, the radio-activity induced is very great (ten times that induced in the open air), and is the same whether the metallic body be charged positively or negatively, but is greater with a negative than with a positive charge when the access of air is unrestricted, though it is comparatively small in this case. In the open air, a negatively charged metal has its side turned away from the more powerfully charged points. In stale air charged with thoria emanations the side farther from the points is not more radio-active than it would have been in any case in presence of these thoria emanations. With the more powerful radio-activity developed as mentioned, the photographic plate showed Kundt's lines splendidly. Kundt's lines show up on the metallic surface when this is brought into air containing smoke or magnesia dust. On connecting the body and points with the terminals of a Tesla transformer, there is no induction of radio-activity in stale air containing thoria emanations. A. D.

1521. *Radio-activity and the Electron Theory.* **W. Crookes.** (Roy. Soc., Proc. 69. pp. 413–422, March 21, 1902.)—Electrons emanating from radio-active bodies behave like material particles, and are impeded by the molecules of the surrounding medium, in contrast with ether waves, which are not thus affected, except by absorption. The author describes experiments in proof of this statement. Actinium (which the author incidentally states to be identical with the body which he called Uranium X in his Royal Society paper of May 10, 1900) and radium give electrons which partake of the properties of a fog or mist of material particles, capable, when not kept in by a thick metal screen, of diffusing away in the free air like odoriferous particles, but the behaviour of polonium is different as regards this diffusibility. Radium emanation may be carried away by a current of air passing over the metal. It will also pass through aluminium and a considerable length of air, and then affect a sensitive film, but experiments on this point with polonium show that air offers great obstruction to penetration by its emanation. Strutt [see Abstract No. 1646 (1901)], has suggested that while the penetrating deflectable Becquerel rays are generally recognised as consisting of a stream of negative corpuscles with high velocities, the non-deflectable and absorbable rays are positive ions moving in a stream from the radio-active body. On this hypothesis, corpuscles from polonium might consist of heavy positive

ions, and the author is now making experiments to test the accuracy of this inference. The author has shown in a previous paper ("Electrical Evaporation," Roy. Soc., Proc. 50. p. 88, June, 1891), that many bodies, such as silver, gold, platinum, &c., usually considered non-volatile at ordinary temperatures, easily volatilise in a vacuum if connected with the negative pole of an induction coil, but remain fixed when connected with the positive pole. When a silver pole was used in a tube of very high vacuum ($P = 0{\cdot}00068$ mm.), and a sheet of mica, with a hole in its centre, placed in front of it, then when the poles were connected with the coil, the silver being negative, electrons shot from it in all directions, and, passing through the hole in the mica screen, formed a bright phosphorescent patch on the opposite side of the tube. After continued action of the coil for some hours it was found that silver had been deposited only on the mica screen and in the immediate neighbourhood of the pole, while the far end of the tube, which had been kept glowing for hours from the impact of electrons, was free of silver deposit. Accepting Strutt's view that positive as well as negative corpuscles will fly off from a radio-active body, we have here two simultaneous actions. Electrons were shot off from the negative pole, and caused the glass on which they impinged to glow with phosphorescent light. Simultaneously, the heavy positive ions of silver, freed from their negative electrons, or under the influence of electrical stress, also flew off, and were deposited in the metallic state near the pole. Experiments were made to see whether these metallic ions, thus deposited on a metal plate connected to an idle pole, in the full stream of + ions and — electrons, showed any special + or — electrification. In all cases the electrification was positive, thus lending support to the view of Strutt, although this result must not be taken as conclusive, for the author has previously shown that, at a high vacuum, nearly the whole of the interior of a tube through which an induction spark is passing is electrified positively. W. C. H.

1522. *Radiography.* **E. W. H. Shenton.** (Roentgen Ray, Archives, 6. pp. 62–70, March, 1902.)—An interesting description is given of surgico-medical routine in radiography as carried out at Guy's Hospital, with an eye to simplicity and the safety of the patient. The need is emphasised of plenty of light, and the practical unimportance of "definition." A. D.

1523. *Diagnosis of Thoracic Aneurysm by Röntgen Rays.* **H. Walsham.** (Roentgen Ray, Archives, 6. pp. 70–74, March, 1902. A paper read at the meeting of the Röntgen Society, June 6, 1901.)—Relates three cases in which the Röntgen rays revealed the existence of aneurysms of the aorta, which were not diagnosed by the ordinary methods of auscultation. Aneurysms of the aorta give abundant evidence of their existence when an examination of the chest is made by Roentgen-ray photography. Often they can be plainly seen by a screen examination. The method should never be omitted in cases of doubtful chest diseases. Eighteen illustrations are given. L. J.

REFERENCE.

1524. *A Method of Obtaining Stereoscopic Effects.* **E. W. Caldwell.** (Elect. Rev. N.Y. 39. pp. 601–603, Nov. 16, 1901.)—A description is given of the means employed to obtain a stereoscopic image in the fluoroscope used in Röntgen-ray work. Two tubes, or a Röntgen-ray tube with a double focus, are employed. J. J. S.

HEAT.

1525. *The Bunsen Ice-calorimeter.* **G. Lindner.** (Phys. Zeitschr. 3. pp. 237–238, March 1, 1902. Communicated by the Physik. Institut der Universität von Erlangen.)—Bontschew (Inaugural Dissertation, Zurich, 1900) has stated that successive experiments with the same specimen show a gradual decrease in specific heat if the ice calorimeter is used. The author proves that this is due to avoidable experimental errors; if the ice formed covers the whole of the tube containing the specimen, and care is taken that it is not below zero, the instrument is thoroughly reliable. In Bontschew's experiments it is probable that there was no ice covering the bottom of the tube, and hence the heat given up by the specimen was not used solely in melting the ice. W. S.

1526. *Heating by Condensation of Steam.* **H. Claassen.** (Zeitschr. Vereines Deutsch. Ing. 46. pp. 418–425, March 22, 1902.)—The details of the transfer of heat through a metallic surface from saturated steam on the one side to a boiling liquid on the other are here studied. No general formula can be given for the transmission-coefficient, owing to the complexity of the effect produced by the variation of any one condition; but the author's general conclusions from elaborate experiments are that this coefficient increases with the temperatures of the steam and of the liquid, and with their difference, but decreases when the height of the liquid column above the heated surface increases, and with rise in the degree of superheating (if any) of the steam. The mechanical condition of the separating surface, apart from rust and scale, and the substances dissolved in the water, have also great influence on the coefficient; thus sugar and organic substances lower it, the effect increasing with their concentration, while salt solutions raise it.

R. E. B.

1527. *Specific Volumes of Oxygen and Nitrogen Vapours at the Boiling-point of Oxygen.* **J. Dewar.** (Roy. Soc., Proc. 69. pp. 360–366, March 7, 1902.)—These values having never hitherto been directly ascertained, this preliminary paper records results of determinations of the vapour densities by actual weighing in spherical glass flasks of 300 c.c. capacity, capable of withstanding pressures up to 5 atmospheres; the necessary precautions and corrections are discussed, and an explanation given of the abnormal figures obtained by Behn by indirect methods. Six determinations at the boiling-point of oxygen, taken as 90·5° absolute, have given as the mean weight of oxygen per litre 4·428 grms., and the specific volume 225·82, numbers which are believed to lie within ½ per cent. of the true value. Taking Regnault's density of oxygen at 0° and 760 mm., the density at 90·5° would normally be 0·0043137, and the specific volume 231·82, which is 1·0246 times the average observed volume, showing that pv is diminished at the boiling point of oxygen by 2·46 per cent. While the ratio of the absolute temperatures is 3·017, the ratio of the densities is 3·091. Further experiments at the same temperature with reduced pressures showed that the ratio of the change of density is greater than that of the change of pressure. Six determinations with nitrogen vapour at 90·5°, and at rising temperatures, proved that its specific volume at 90·5° is 256·833, from which it is calculated,

from the formula $T = v\ 90{\cdot}5/256{\cdot}833$, that, at its own boiling-point of 78° absolute, it would be 221·3, as against 226·2, the similar value found for oxygen. In the case of hydrogen, the next of these values to be accurately ascertained, there will be great manipulative difficulties at 21° absolute, and, as the pressure in the weighing flask will be nearly 15 atmospheres, it will be advisable to construct it of some metal or alloy [see also Abstracts Nos. 1288 (1901) and No. 45 (1902)]. S. R.

1528. *Cooling by Liquid Air.* **d'Arsonval.** (Soc. Int. Élect., Bull. 2. pp. 177–203, March, 1902.)—The author gives first a brief historical *résumé* of the means employed for reaching low temperatures, and describes in detail Linde's apparatus for producing liquid air. In this, air is compressed to 220 atmospheres and allowed to expand; the machine differs from Hampson and Tripler's in that these employ one expansion while Linde employs two, the first to 50 atmospheres and the second to atmospheric pressure. By using this double expansion, Linde was able to diminish the size of his compressor to one-fifth of that required in Hampson and Tripler's apparatus. The author then describes the flasks with vacuum jackets used for keeping liquid air, and states that the small quantity of heat which reaches the inner vessel does so by conduction across the junction between the two vessels. He then deals at length with the properties of liquid air and the uses to which it can be put, and describes experiments made by Armagnat and himself on the magnetic properties of iron and steel at the temperature of liquid air. Bar magnets of Allevard steel were found to lose their magnetism to a small extent in cooling from + 10° to — 190° C.; the percentage loss varied from 1·3 to 4·25 in different specimens. A table is given for values of H and B for a ring of soft iron, at + 10° and — 190° C. For low values of B the permeability is less at the lower temperature, while for B above 15,000 it is slightly greater. The heat of vaporisation of liquid air is found by the author to be 65 calories. He measured also the specific heat of air at — 100° C. at different pressures; the figures obtained are :—

Pressure in atmospheres ...	10	20	38	75
Specific heat	0·2585	0·284	0·375	0·866

[See also Abstract No. 468 (1902).] G. H. B.

1529. *Cooling Power and Conductivity of Air.* **P. Compan.** (Comptes Rendus, 134. pp. 522–524, March 3, 1902.)—This is a continuation of previous work [see Abstract No. 308 (1902)]. In a blackened metal flask, 14·5 cm. in diameter, for temperature differences from 300° to 0°, the cooling power of air at pressures between 50 mm. and 4,480 mm. (6 atmospheres) is represented by Dulong and Petit's formula $np^c t^b$, where $b = 1{\cdot}23$ and $c = 0{\cdot}45$, values the same as those found by Dulong and Petit for pressures smaller than the atmospheric. The formula also represents the cooling power of air as affecting a ball in an indefinitely extended medium. When the air has a movement of translation, velocity u, its cooling power is $kt\sqrt{u}$, as Boussinesq predicted (Comptes Rendus, 133. p. 257). A. D.

1530. *Melting of Binary Solid Mixtures by Cooling.* **Bakhuis Roozeboom.** (Konink. Akad. Wetensch. Amsterdam, Versl. 10. pp. 727–731, March 29, 1902.)—The phenomena corresponding to the passage of mixtures from one state of aggregation into another are much more complicated than those exhibited by a single substance, the order of those states being sometimes inverted.

The first example known is the retrograde condensation of a solid separating out by evaporation and dissolving again. The author's theoretical study on transformations of binary solid mixtures [see Abstract No. 679 (1900)] suggested to him the possibility of similar phenomena ; the case of mixture crystals separating by cooling into a solid and a liquid phase was, however, not realised until now, as adequate examples were missing. Now, De Kock having met with a most striking example of mixture crystals in the liquid state, in the case of mixtures of azoxyanisol and hydroquinone, the author considers very fully the phenomena exhibited by those systems, maintaining that this case of retrograde solidification (provided the liquid crystalline state be regarded as solid) may be no exceptional one. He finally points out the similar case of solid mixture crystals α discovered recently by Heycock and Neville [see also Abstract No. 1382 (1902)]. A. G.

1531. *Cryoscopic Researches.* **P. Chroustchoff.** (Jurn. Russk. Fisik. Chimičesk. Obščestva, 34. 2a. pp. 153–182 ; and 3a. pp. 323–350, 1902.)—The method of measuring temperatures by means of an electric thermometer, as suggested by the author, is found to be the most sensitive, accurate, and certain method of investigating the lowering of freezing-points of solutions, its main advantages being its sensitiveness to less than 0·0005°, and its being capable of still further perfection by simple alterations. An additional advantage is that the results are obtained as temperature differences. The lowering coefficient C/P, and therefore the molecular lowering CM/P as well, is dependent upon the degree of dilution in a manner which varies with different aqueous solutions. The laws of variation of this coefficient do not confirm the views of Arrhenius of a direct analogy existing between these phenomena and those of dissociation [see also Abstract No. 413 (1901)].

A. G.

REFERENCE.

1532. *The Second Law of Thermodynamics.* **K. v. Wesendonck.** (Ann. d. Physik, 7. 3. pp. 576–583, March, 1902.)—This is a contribution in support of the author's views and in criticism of Wiedeburg's. [See Abstracts Nos. 80 and 2128 (1901).] R. E. B.

SOUND.

1533. *Singing Pipes.* **C. Maltézos.** (Comptes Rendus, 134. pp. 701–703, March 24, 1902.)—At the embouchure of a pipe there is an inrush of air below so long as the pipe is sounding, as well as an outrush of air above. This inrush seems to be continuous with the outrush, so that NH_4Cl smoke or tobacco smoke drawn in by the inrush below will emerge by the outrush above. The inrush is periodically intermittent. If any air-currents in the neighbourhood of the embouchure be hampered, the pitch of the pipe alters. A. D.

1534. *Air-Pressures in Brass Instruments.* **E. H. Barton** and **S. C. Laws.** (Phil. Mag. 3. pp. 385–393, April, 1902. Paper read before the Physical Society, Dec. 13, 1901.)—The instruments examined were the tenor trombone, the trumpet, and the cornet, and the relationship of pressure of blowing to the pitch, intensity, method of fingering and nature of the instrument was investigated. The pressure was read by a water manometer connected to the performer's mouth by an indiarubber tube and glass nozzle. This, after some practice, did not inconvenience the player. Tables of figures and curves are given showing the results when any three of the four variables mentioned above are kept constant, and the fourth is allowed to have its special connection with the air-pressure exhibited. The following results are arrived at:—(1) The louder the note the greater the pressure; (2) the higher the pitch the greater the pressure; (3) for a given intensity, the pressure is approximately proportional to the logarithm of the frequency; (4) alternative methods of fingering have practically no effect on the pressure required, pitch and intensity being kept constant; (5) the pressures for cornet and trumpet are almost the same, the same note being produced at the same intensity; the pressure for the trombone is very much greater. J. W. P.

1535. *Decimal Scale for Music.* **A. Guillemin.** (Comptes Rendus, 134. pp. 980–982, April 28, 1902.)—The author proposes to replace the octave and the comma (the usual large and small units of interval) by the savart and the millisavart, defined as follows: The savart to be the interval 10 : 1 (equivalent to 3 octaves and a major third) and the millisavart the thousandth part of this, *i.e.*, the interval given by the thousandth root of 10 : 1 or approximately 435 to 434. With these units all calculations will be much simplified. The formulæ giving any interval m to n in terms of the savart and the millisavart will become respectively $\log \frac{m}{n}$ and $1000 \log \frac{m}{n}$, replacing, in the old notation, the expression $\left(\log \frac{m}{n}\right) \Big/ \left(\log \frac{2}{1}\right)$ in terms of the octave, and $\left(\log \frac{m}{n}\right) \Big/ \left(\log \frac{81}{80}\right)$ in terms of the comma. The tempered semitone is very nearly 25 millisavarts, and the millisavart, although not appreciable by the ear as an interval, may be easily apprehended by the beating, at the rate of one per second, of the notes 435 and 434, which lie in a convenient part of the scale. It is also proposed, as a consequence of these results, that the standard international fork should be taken as 434·3. J. W. P.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

1536. *Asymmetry of the Electro-capillary Curve.* **J. J. van Laar.** (Konink. Akad. Wetensch. Amsterdam, Versl. 10. pp. 753–769, March 29, 1902.)—(1) An accurate theoretical consideration of the capillary electrometer shows that the surface-tension expressed in terms of the charge of the double stratum is not represented adequately by the equation $\gamma = \phi_0 - k\omega^2$, but by the more complicated relation $\gamma = \varphi_0 - A\omega - (k + \beta)\omega^2$. (2) The coefficients A and β are not equal, in the case of the solution being charged negatively, to their values in the case of an equal positive charge; in the former case $k + \beta$ is more than double those values, A being negative in the former, positive in the latter case. (3) The electro-capillary curve consists of two parabolic branches entirely different from each other, contiguous in the case of $\Delta = 0$, the rising branch being much more abrupt than the falling branch. (4) The rising branch will exhibit a maximum, not necessarily corresponding to $\Delta = 0$; for the example tested, the difference is as large as 40 millivolts. (5) This proves sufficient to account for all such peculiarities of the electro-capillary curve as had hitherto remained unexplained. (6) According to (4), Lippmann's capillary electrometer fails to afford an adequate means of determining the exact value of the potential difference between a metal and an electrolyte. A. G.

1537. *Loss of Life by Lightning in the United States.* **A. J. Henry.** (U.S. Weather Bureau, Bull. 30. pp. 7–21, 1901.)—The statistics cover the eleven years 1890 to 1900; but as the compilers had largely to rely upon newspapers and clipping bureaux, the inquiry was abandoned at the end of 1900. From 700 to 800 people were killed each year, 713 persons being killed by lightning in 1900, and 973 injured. The Middle Atlantic States and the Ohio Valley, further Tennessee and the Middle and Upper Mississippi Valley are most endangered; the mortality is very high in the Middle Rocky Mountains, considering the sparsity of the population. The main body of the bulletin is taken up by general remarks on thunderstorms and their dangers, partly reproduced from bulletin 26. There are notes on electric duststorms with abundant but noiseless flashes of light, and two weather maps of the United States, the one of July 8, 1898, showing thunderstorms south-west of a low-pressure area, and the other of June 25, 1901, thunderstorms in an area of high pressure. H. B.

DISCHARGE AND OSCILLATIONS.

1538. *Influence of Dielectric on Spark-length.* **S. Lussana** and **P. Carnazzi.** (N. Cimento, 3. pp. 132–138, Feb., 1902.)—On bringing up a strip of glass until its upper edge stands between the centres of two spark-gap spheres, if it be close to the anode, the ratio δ between the new spark-length and the original spark-length increases rapidly at first, and then less rapidly, with the thickness of the glass. As the glass is moved further from the anode the values of δ increase, reach a maximum, and fall back to unity. On

increasing the diameter of the spheres, the values of δ increase. As potential-differences rise, the values of δ fall, reaching unity. Other dielectrics act in similar ways. On making the spark pass from a sphere to a liquid the results are similar. A small insulated conductor has no such effect up to or near the anode. A. D.

1539. *Spark Spectra of Iron in Liquids, and in Air at High Pressures.* **G. E. Hale.** (Astrophys. Journ. 15. pp. 132–135, March, 1902.)—In these experiments, of which this is a preliminary account, the spectrum of the iron spark has been investigated, both when the discharge is under water or various solutions and also when in air at different pressures. The current was obtained from a 15,000-volt transformer, and the discharge was made between steel electrodes 1 mm. in diameter and about 1 mm. apart; an auxiliary spark-gap 12 mm. long was also used in series, and a condenser of about 0·0015 microfarad capacity. A series of photographs is reproduced showing the spectrum of the spark in water and salt solutions and in other liquids. Under certain conditions many of the principal lines are reversed, this being especially marked when such liquids as kerosene are employed, or salt solutions, the maximum effect being produced in a 9·5 per cent. solution of $BaCl_2$. Within limits, the reversals increase in number and intensity: (1) with length of auxiliary air-spark; (2) with the diameter of the electrodes of either spark; (3) with the capacity of the condenser; (4) with the pressure of the water; (5) with the concentration of the solution, when sodium chloride or other salts are dissolved in the water. On the other hand, an increase in the length of the spark tends strongly to diminish the reversals. In addition to the above, no reversal is to be found in the following cases. The spark in a Wehnelt interrupter (iron rod in potash solution with a direct current of 110 volts). The arc between rotating iron poles in water. The spark from a large Apps coil between iron poles in water. The discharge from a high frequency coil between iron poles in water. The blue region of the spectrum of the transformer sparks in air has also been observed at pressures up to 20 atmospheres. Results were obtained in agreement with those of Humpheys and Mohler at lower pressures; the lines remain sharp, and are shifted towards the red by an amount which seems to be proportional to the pressure. The phenomena are thus quite different from those observed in water. A series of photographs are also reproduced showing the transition from the bright line to the dark line spectrum; these were taken with a 21-ft. grating with the spark in water under varying conditions. E. C. C. B.

1540. *Asymmetry in Alternate-current Discharge.* **W. Mitkiewicz.** (Jurn. Russk. Fisik. Chimičesk. Obščestva, 34. 2b. pp. 17–29, 1902.)—These researches were undertaken with the view of testing the asymmetry of alternating currents traversing a gaseous medium between electrodes of different character. The author accordingly studies the case of the voltaic arc produced by a direct current between two such electrodes; the back electromotive force being determined by a direct-compensation method. The results obtained agree fairly well with Duddell's data in order of magnitude, but are much inferior to those of other observers. The slight differences found to exist, according to the direction of the current, may very well explain the small dissymmetries shown by an alternate-current arc less than 1 mm. in length, but fail to account for those corresponding to Blondel's *second régime*. It is therefore suggested that selective conductivity may play a considerable part in those phenomena, the medium once traversed by a discharge opposing a

greater resistance to discharges occurring in the opposite direction. The work of previous observers is very fully discussed, and tables are given for the back e.m.f., these values ranging from 6 to 17 volts in the cases considered.
A. G.

1541. *Kathode Rays.* **G. Leithäuser** and **E. Warburg.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 14. pp. 267–269, March 6, 1902.)—When we use the homogeneous rays from an influence machine, not from an induction coil, we find that passing them through a thin lamella of metal renders them non-homogeneous and diversely deviable, so that they may form a magnetic spectrum.
A. D.

1542. *Electrical Oscillations in Coils.* **E. Lüdin.** (Ann. d. Physik, 7. 3. pp. 584–538, March, 1902.)—Following Hertz, it is usual to generate electric vibrations by spark discharges. They are, however, equally obtainable on opening or closing a simple circuit containing a battery and a coil of a sufficient number of turns. This result may be deduced theoretically by noting that the coil has capacity. The oscillations were experimentally detected by a coherer attached to, and projecting from, one end of the coil. The effect was more marked on opening than on closing the circuit. By this arrangement stationary waves were also obtained along a wire, their presence being shown by well-marked nodes and anti-nodes detected by the coherer. The coil used was in five sections, and had in all 2,823 turns, a resistance of 12·35 ohms, and an inductance 0·166 henry. Currents from 0·1 to 0·8 ampere were used. The author feels that the effects here investigated may afford the explanation of some of the disturbances experienced at the receiving station in Marconi telegraphy, the mechanism there used probably generating waves which affect the coherer.
E. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1543. *Contact Differences of Potential between Amalgams and Electrolytes.* **L. Poincaré.** (Comptes Rendus, 134. p. 527, March 3, 1902.)—Referring to a paper by P. Boley [see Abstract No. 1105 (1902)], the author mentions having described a capillary electrometer for measuring the contact differences of potential between amalgams and electrolytes before the French Association for the Advancement of Science at the congress held at Marseilles in 1891. The author obtains certain curious results with an amalgam of tin in the presence of sulphuric acid; for this amalgam, the value of the e.m.f. which makes the capillary constant a maximum is practically zero at ordinary temperatures, consequently, an electrometer constructed with this amalgam gives readings independent of the sign of the applied e.m.f.
E. C. R.

1544. *Change of Electrical Conductivity of a Powder by Induction.* **H. Muraoka** and **T. Tamaru.** (Ann. d. Physik, 7. 3. pp. 554–561, March, 1902.)—Following up the work of Sundorph [Abstract No. 1717 (1899)], the authors experimented with a circuit containing a battery, galvanometer, and the powder under test. The change of conductivity of the powder consequent upon closing a shunt-circuit through it was noted. Sundorph found an increase of conductivity in iron and nickel, which he attributed to fusion of the particles. The present authors thought the effect might have a magnetic origin, and therefore tried brass and carbon dust. The brass gave the same

effect as the other metals, but the carbon the opposite effect. A theory is then developed mathematically, and tested by further experiments on brass dust; an approximate confirmation of the chief result being obtained, viz., that the reduction of the resistance of the powder is smaller, the smaller the inducing current, and the greater the volume of the powder. E. H. B.

1545. *Electrostatic Relay.* **V. Crémieu.** (Comptes Rendus, 134. pp. 524–526, March 3, 1902.)—If a circuit contact cannot be made by pressures less than some centigrammes' weight, and if supplementary pressures be added to the initial pressures in a registering mechanism, there is a tendency to solder the contacts together, and to make the pull-off difficult. The electrostatic relay now described, for use with the author's absolute electrometer, obviates these difficulties by making connections through an electrostatic quadrant. This gets rid of sparks. A. D.

ALTERNATING CURRENTS AND MAGNETISM.

1546. *Action of Alternating Currents on Direct-Current Armatures.* **L. Fleischmann** and **A. Orgler.** (Elektrotechn. Zeitschr. 23. pp. 258–260, March 27, 1902.)—The authors simplify Latour's explanations [see Abstract No. 334 (1902)] of the effects produced by passing alternating currents through ring-wound direct-current armatures. The case of an alternating current sent through two brushes diametrically opposite to one another on the commutator is first considered. It is shown that, whatever the speed with which the brushes are made to rotate round the commutator, the impedance between them is constant. This is proved analytically, and illustrated graphically by diagrams giving the values of the currents at various instants in the coils for different positions of the brushes. The case of four rotating brushes placed at equal distances apart round the commutator, the brushes being connected to a two-phase system of supply, is next considered, and the problem is solved on the ordinary sine assumptions. It is shown that the impedance between an opposite pair of brushes is a function of the speed with which the armature rotates. When the armature-speed is in synchronism with the period of the alternating current then the impedance is the same as the resistance, and hence the reactance is zero. It is thus possible to excite the iron of the core in exactly the same way by means of two-phase currents as by means of direct-current field magnets. The applications of this by Heyland are mentioned [see also Abstract No. 502 (1902)]. A. R.

1547. *The Rectified Alternate Current.* **A. Gerschun.** (Phys. Zeitschr. 3. pp. 249–254, March 15, 1902.)—This is a theoretical investigation, the e.m.f. in the circuit being a rectified sine e.m.f. The curve representing the e.m.f. in terms of the time is thus obtained by rotating the negative part of the usual sine curve through 180° about the time axis. The expression for the e.m.f. is a Fourier series proceeding by even multiples of ωt, where ω is 2π times the frequency of the primary rectified current. Solution of the differential equation of current for a single circuit with self-inductance leads to the following results: The mean current depends solely on the resistance; if the circuit possesses any inductance, the instantaneous value of the current is never zero; the amplitude of the current fluctuations is the smaller, the larger the time-constant of the circuit; the current curve is symmetrical with

respect to its maxima and minima; the lag of the current can be only approximately calculated. Those results are easily confirmed by observations with a Braun tube and rotating mirror. The author finds also the ratio of the effective current as indicated by an electromagnetic continuous-current ammeter to the instantaneous current; the greater the self-inductance the more nearly does this ratio approach unity, and for zero inductance it is approximately 1·11. With zero inductance Mitkiewicz [see Abstract No. 2436 (1901)] has found the ratio to be as high as 1·7, which is due to deviation of the e.m.f. from the sine form and to complications introduced by the rectifier. If the circuit contain capacity as well as inductance, we get an alternating current of mean value zero; no compensation of inductance by capacity is possible as it is with ordinary alternating currents. In view of Zenneck's experiments [see Abstract No. 190 (1900)] the author considers also the case of an ideal transformer whose primary contains the rectified sine e.m.f., using Heaviside's method of symbolical solution of the differential equations. The current in the primary is a pulsating current whose instantaneous value is never zero and whose amplitude is smaller the smaller the resistance of the secondary. The current in the secondary is alternating, and its theoretical value is in complete agreement with Zenneck's found by experiment. Zenneck thought that his results were due to deviation of the e.m.f. from the rectified sine form, or to hysteresis, or to complications caused by the rectifier, but in reality they are the necessary consequences of a rectified sine e.m.f. in the primary. W. S.

1548. *Accurate Measurement of Large Phase-Differences.* **M. Breslauer.** (Zeitschr. Elektrotechn., Wien, 20. pp. 53–57, Feb. 2, 1902.)—For the measurement of power-factors of the order of 0·1, a wattmeter is unsuitable, since even under the most favourable conditions, viz., when the pressure and current coils are both loaded to their full capacity, the available part of the scale becomes reduced to $\frac{1}{10}$, and when the conditions are less favourable, to a still smaller fraction of its full range. A very large error must under these circumstances be expected. The author describes the following arrangement, which has given very satisfactory results. The inductive load is joined in series with a non-inductive resistance, as in the 3-voltmeter method, and two readings are taken with a suitable differential galvanometer (or electromagnetic voltmeter), one of whose coils is arranged as a shunt across the non-inductive, and the other across the inductive, part of the circuit, the connections of either coil being reversed for the second reading. The first reading measures the geometrical sum, and the second the geometrical difference, of the p.d.'s across the inductive and non-inductive parts of the circuit. By reasoning similar to that employed in connection with the 3-voltmeter method, it is easy to show that if e_s and e_d be the readings (in volts) of the differential instrument in the two cases, and r the value of the non-inductive resistance, then the power in the inductive part is given by $(e_s^2 - e_d^2)/4r$. The author gives examples of measurements by this method, which are very consistent with each other. A. H.

1549. *Magnetostriction of Nickel-Steel.* **H. Nagaoka** and **K. Honda.** (Comptes Rendus, 134. pp. 536–538, March 3, 1902.)—The anomalous thermal expansion of the alloys of nickel and iron adds interest to this research. The alloys have the following percentage of nickel:—(*a*) 25 per cent.; (*b*) 29 per cent.; (*c*) 36 per cent.; (*d*) 46 per cent. These letters will be used below. *Variation in Length.*—(*a*) Not sensibly magnetic, no length change,

(*b*) sensibly magnetic, varies in length slowly with field; (*c*) strongly magnetic, varies at first rapidly, but soon approaches a limit; (*d*) is intermediate between *b* and *c* in properties. *Variation in Volume.*—This becomes less as the alloys are more strong in nickel. It is significant, as showing how little thermal changes influence these observations, that whereas *c* has a coefficient of thermal expansion about one-tenth as much as *b* and *d*, its variations in dimensions are intermediate between those of the other alloys. [See also Abstract No. 879 (1901).] P. E. S.

1550. *Magnetostriction of Nickel-Steel.* **C. E. Guillaume.** (Comptes Rendus, 134. pp. 538–539, March 3, 1902.)—This paper refers to the foregoing research of Nagaoka and Honda. The smallness of the changes observed leads one to think that the result may be due to purely thermal causes. If susceptibility increases with temperature, we should expect, using Carnot's principle, that any increase in field would be accompanied by elevation of temperature. L. Dumas has propounded the theory that for the alloys having a small percentage of nickel, the magnetism is like that of iron; but that for alloys with more than 25 per cent. of nickel, the magnetic properties will be like those of this metal. At first sight the results of Nagaoka and Honda seem in direct opposition to the theory of Dumas. But as this theory is so satisfactory in other ways, the author considers that fuller research, taking temperature change into account, will very likely confirm it. P. E. S.

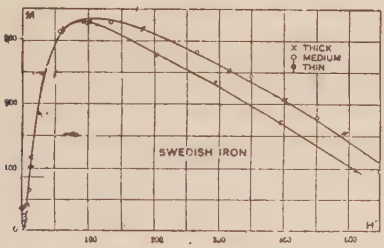
1551. *Magnetostriction of Nickel-Steel.* **F. Osmond.** (Comptes Rendus, 134. pp. 596–598, March 10, 1902.)—The author points out that Dumas's theory fails, as Guillaume shows, in reference to the research of Nagaoka and Honda (see preceding Abstract), and also in two other ways. (1) The exceptional dilatation of certain of the alloys can only be explained by supposing that a contraction of one constituent opposes the expansion of another, due to the gradual transformation of crystalline constituents. (2) The magnetic power of these alloys (*i.e.*, those having reversible magnetism) is much too great to be attributable to nickel alone. P. E. S.

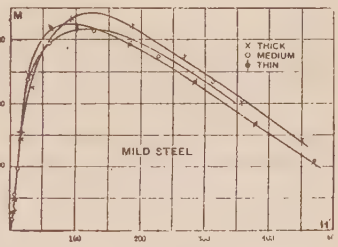
1552. *Stability of Magnetism, Temporary and Permanent.* **M. Ascoli.** (N. Cimento, 3. pp. 5–70, Jan., 1902.)—This is an exhaustive paper, in which the author traces out an area within the area of the hysteretic diagram, within which inner area the magnetisation is not affected by shock. A permanent magnet perfectly stable to shock may always be obtained by adjusting magnetisations and demagnetisations, the experimental methods involved being in practice relatively easy to carry out. The percentage of permanent magnetism which must be sacrificed in order to secure stability under shock is greatest for iron, least for tempered steel; and it is almost independent of the magnetising force applied. In iron it is about 65 per cent., and does not depend on the form of the iron; with steel it varies from 7 to about 20 with the form of the metal; with tempered steel it varies from about 0·2 to about 0·9 per cent. In tempered steel, even though the magnetisation be not uniform, it is possible to attain approximately perfect stability in all points of the metal. A. D.

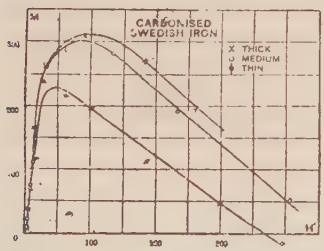
1553. *Magnetic Expansion of Iron and Steel.* **P. E. Shaw** and **S. C. Laws.** (Electrician, 48. pp. 699–702, Feb. 21; and pp. 765–767, March 7, 1902.)—This paper deals with the continuation of experiments previously described in the Electrician [see Abstract No. 1331 (1901)], which were carried out by the aid of Shaw's Electric Micrometer [see Abstract No. 523 (1901)]. The

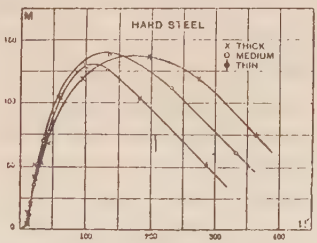
materials investigated were : (1) Swedish iron ; (2) mild steel ; (3) hard steel. In each case rods of diameters 5 mm., 4 mm., 3 mm., 2 mm., 1 mm., and ½ mm. were employed. The true magnetising force H′ is given by the relation $H' = H - NI$ where $H = 4\pi ni$, and N is a constant depending on the length and diameter of the rod. The values of N for cylinders and rods are given in Du Bois' "Magnetische Kreise," having been worked out experimentally for all the sizes employed by the authors. From the equation given $H' = 4\pi ni\,(1 + Nk)$, where k is the magnetic susceptibility, the susceptibility is found by the ballistic method, the materials being made into rings, and welded with the greatest care to preserve continuity at the joint.

To obtain the value for H′ the following process is employed. Assume a value for H′, and from the susceptibility curve for the specimen find the corresponding value for k, hence $1+Nk$ is known, and dividing this into the uncorrected value for H, viz., $4\pi ni$, a value for H′ is obtained. If this agrees with the assumed value of H′ this value is adopted. If not, proceed by









taking a fresh value for H′ and so on until the two values of H′ agree. The results obtained are given in the curves, M, the alteration in length, being in cms. $\times 10^{-7}$, the length of the specimens is about 8·5 cm., and the diameters 5, 4, and 3 mm. The conclusions obtained are thus summarised : Even if the chemical composition of specimens be identical, and they be repeatedly annealed from a temperature of bright redness, there is found an irregularity of behaviour which indicates that the ultimate molecular structure is very heterogeneous. Regularity of expansion is obtained when a reading under like conditions has been repeated many times. This shows that the cause of the irregularity is in the particles, which gradually take up a definite position under definite treatment. If H be the field required to produce the maximum elongation, and a field H′ greater than H be put on, the rod first expands and then contracts. When the field is put off, the rod expands again to its maximum, and then contracts to its stable state. Thus the rod undergoes every stage in expansion up to the point in question, and does not take a short cut as might be expected. This effect is to be attributed to the self-induction of the magnetising coil, whose time constant is large enough to allow the rod to expand progressively as the field changes. E. C. R.

1554. *Magnetisation at —185° C.* **C. C. Trowbridge.** (Phys. Rev. 14. pp. 181–191, March, 1902.)—Dewar and Fleming (Proc. Roy. Soc. 1896) investigated the effect on the magnetic moment (M) of suddenly cooling steel magnets to — 185° C. The author magnetises at — 185°, by placing the steel bars in liquid air surrounded by an air jacket round which is a coil. He then compares their values of M with those of the same bars magnetised at 20°. He also raises the cooled and magnetised bar to 20°, and determines any resulting change in M. His conclusions are : (1) Approximately the same M is obtained in carbon—or tungsten—steel, whether the bar is magnetised at 20° or at —185°. (2) The initial loss in M, due to change in temperature, of a bar magnetised at — 185° and then heated to 20°, is much greater than when the bar is magnetised at 20° and cooled to — 185°. (3) A certain amount of unstable magnetism exists, which tends to pass off at the first change in temperature, either way ; but much more passes by heating than by cooling. P. E. S.

1555. *Effect of a Transverse Magnetic Field on Metallic Resistance.* **J. J. Thomson.** (Phil. Mag. 3. pp. 353–356, March, 1902.)—In a report presented to the International Congress of Physics at Paris, 1900 [see Abstract No. 1672 (1901)] the author arrived at the conclusion that, on the theory that the electric current in a metal is carried by charged particles moving freely through the metal, the resistance should be increased by a transverse magnetic force. The opposite is the conclusion of van Everdingen [see Abstract No. 862 (1902)], whose results are based on the following assumptions :—(1) That the corpuscles which carry the current behave like a perfect gas ; (2) that the collisions which the corpuscles make with the molecules through which they move are similar to those which take place between hard elastic bodies ; (3) that the corpuscle between two collisions is free from any force except that due to the external field producing the current. In the present paper the author gives reasons for adhering to his original view. He states that the second assumption of van Everdingen is not likely to be true, but that a collision ought to be regarded as consisting of a deflection of the path of the corpuscle, due to the force exerted on it by a molecule near to which it passes ; on this supposition it is highly improbable that the resistance should be diminished by the field. Thomson also denies the truth of van Everdingen's third assumption. The corpuscles are highly charged, and are always within distances of less than 10^{-7} cm. of the molecules of the metal ; it is almost certain, therefore, that the local forces exerted on the corpuscle by the surrounding molecules are enormously greater than those exerted by the external electric field, and that at the end of its free path the corpuscle rushes into or past the molecule with which it is colliding with a velocity very large compared with that with which it started. The result obtained by van Everdingen was deduced from hypotheses leading to large values for quantities which, though uncertain as to magnitude, are undoubtedly very small. W. S.

1556. *Magnetic Observations at Potsdam,* 1890 *to* 1899. **G. Lüdeling.** (Phys. Zeitschr. 3. pp. 203–207, Feb. 15, 1902. From Abhandlungen des Königl. Preuss. Meteorolog. Instituts. 1. No. 8. p. 54, 1901.)—Attention is drawn to the vector diagrams of the original. The distinction of summer and winter semesters is less instructive than Lloyd's grouping into winter, summer, and equinoctial months (March, April ; September, October). The horizontal components show a double annual period with maximum about

the summer solstice, secondary maximum about the winter solstice; the vertical and total intensity a single period, maximum in February, minimum in June–July. The secular variations seem to indicate that we are approaching a turning-point, but the registering instruments are not very reliable. The declination is decidedly decreasing, but may continue to do so for 120 years. A table is added of the chief magnetic disturbances; they correspond with the auroræ, and, if taken, not singly, but for the whole year, with the sunspots. H. B.

REFERENCES.

1557. *Condenser Effects with Rotating Disks.* **A. G. Dell.** (Elect. World and Engineer. 39. pp. 550–551, March 29, 1902.)—A brief account of some further experiments on the behaviour of rotating disks when electric sparks are passed underneath them parallel to the plane of the disks. [See Abstracts Nos. 1310 (1901) and 1343 (1902).] W. C. H.

1558. *Ionised Gases.* **P. Langevin.** (Comptes Rendus, 134. pp. 414–417, Feb. 17, 1902.)—An account of some experiments which confirm the theory of the ionisation of gases, and a theoretical discussion of some deductions from the theory. J. J. S.

1559. *Disruptive Discharges.* **K. R. Johnson.** (Écl. Électr. 30. pp. 385–389, March 15, 1902.)—A short paper in continuation of the work dealt with in Abstract No. 1097 (1901). E. H. B.

1560. *Propagation of Electric Vibrations in Water.* **E. Cohn** and **P. Zeeman.** (Archives Néerlandaises, 7. pp. 1–9, 1902.)—This is a French translation from the Konink. Akad. Wetensch. Amsterdam, Verslagen, 1895. G. W. DE T.

1561. *Measurements of the Absorption of Electric Vibrations in Electrolytes.* **P. Zeeman.** (Archives Néerlandaises, 7. pp. 10–27, 1902.)—This is a French translation from papers in the Konink. Akad. Wetensch. Amsterdam, Verslagen, 1895 and 1896. G. W. DE T.

1562. *Reiniger, Gebbert, and Schall's Mercury-jet Interrupter for Induction Coils.* **H. Boas.** (Elektrotechn. Zeitschr. 23. p. 208, March 6, 1902.)—In this paper references are given to various publications with a view to showing that this type of interrupter [for which see Abstract No. 1103 (1902)] was known early in 1898. C. K. F.

1563. *The Induction Coil.* **W. Rollins.** (Elect. Rev. N.Y. 40. pp. 406–411, March 29, 1902.)—Practical directions are given for the construction of a 70-cm. induction coil suitable for the powerful currents needed in wireless telegraphy and in Röntgen-ray work. The secondary coil is made up of separate sections and contains only 13 kg. of copper. A. D.

1564. *Form Factor and Amplitude Factor.* **G. Benischke.** (Zeitschr. Elektrotechn., Wien, 20. pp. 157–159, March 30, 1902.)—A paper in which the author considers the relative importance of these two factors, and arrives at the conclusion that the amplitude factor is more important than the form factor. A. H.

1565. *Magnetic Tests of Iron.* Report of the Sixth Commission. **H. Armagnat.** (Soc. Int. Élect., Bull. 2. pp. 172–176, March, 1902.)—Suggestions are drawn up as to the several details about which care should be taken in commercial tests on permeability and hysteresis. The suggestions form the basis of a discussion to take place at the next meeting. [See also Abstract No. 1482 (1900).] P. E. S

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1566. *Calculation of Atomic Weights.* **J. Schmidt.** (Zeitschr. Anorg. Chem. 31. 1. pp. 146–154, 1902.)—It is assumed that chemical attraction obeys the universal laws of attraction between particles of matter, *i.e.*, is a force proportional to the product of the weights of the effective masses. The author next suggests that to every equivalent value of an atom there corresponds a definite part b of the atomic weight, in addition to a portion chemically ineffective a, wanting in the case of hydrogen only. Monovalent atoms are hence represented by $a + b$, bivalent by $a_1 + b_1 + b_2$, and so on. In order to calculate these quantities a and b, it is presumed that in the case of the elements of the two first series, viz., in the case of those atoms which possess greatest chemical energy and least proper weight, there exist the most simple numerical relations. The values for the atomic weights thus calculated for these, and for the two following series, are in very satisfactory accordance with those found by experiment. Conclusions are drawn from a comparison of the calculated atomic weights with molecular volumes. A. G.

1567. *Atomic Weight of Antimony.* **G. C. Friend** and **E. F. Smith.** (Chem. News, 85. pp. 124–125, March 14, 1902. From Journ. Amer. Chem. Soc. vol. 23, No. 7.)—The paper describes application to antimony of the authors' new method of heating a potassium or sodium salt in dry HCl, and weighing the residual alkaline chloride, by which they lately determined the atomic weights of molybdenum and arsenic. Very carefully purified antimonyl potassium tartrate was placed in a small porcelain crucible enclosed in a larger one with two holes in the lid, and very cautiously heated in a steady stream of pure dry HCl gas, the temperature finally reaching dull redness. Oxygen was passed to remove the carbon, and then again HCl. Platinum crucibles could not be used, as they were very severely attacked. The atomic weight of antimony, as deduced from the weight of potassium chloride remaining, was, in eight experiments, maximum 120·385, minimum 120·311. Barium and silver antimonyl tartrates crystallise well, but have not given satisfactory results by this method. S. R.

1568. *Valency of Oxygen and the Halogens.* **H. Stanley.** (Chem. News, 85. pp. 133–134, March 21, 1902.)—A theoretical paper supporting the thesis that these elements can assume a higher valency than the normal (quadrivalent in oxygen and trivalent in the halogens), especially in compounds having *like* atoms combined, and in which there is a lower stability. A parallelism is drawn between hydrazoic acid HN_3, ICl_3, and the (as yet) hypothetical HI_3 from KI_3. In peroxides and acids, such as chloric and nitric, which easily lose one atom of oxygen, this atom is considered to be attached by two bonds to a quadrivalent oxygen, which latter returns to its normal dyad character after the decomposition. A formula of this character, $Et_2 = O = O$, had been already suggested by Collie for ethyl peroxide. The breaking-up of mercurous oxide is represented as—

$$Hg = O = Hg \longrightarrow Hg = O + Hg.$$

Arguments in favour of the proposed new formulæ are deduced from the increasing stability in the series of oxyacids of chlorine, the dissociation of ICl_3, and the existence of complex fluorides. S. R.

1569. *Atomic Weight of Calcium.* **T. W. Richards.** (Zeitschr. Anorg. Chem. 31. 2. pp. 271–275, 1902.)—Most uncertain data have hitherto been current as to the atomic weight of calcium, in spite of its wide distribution. In order to obtain pure calcium chloride, the author transformed some Rutland marble into the nitrate, and purified it by repeated crystallising. From the specimens thus obtained the carbonate was precipitated by pure ammonium carbonate, this product being next transformed into the chloride. The precautions used in analysing the latter are described, the results showing that three specimens tested were almost identical. The mean value 40·126 obtained for the atomic weight agrees closely with the value 40·142, derived from the recent measurements of Hinrichsen, carried out without any knowledge of the author's work. Further investigations by other methods are being made at Harvard College. A. G.

1570. *Classification and Atomic Weights of Neon, Argon, Krypton, and Xenon.* **H. Wilde.** (Comptes Rendus, 134. pp. 770–772, April 7, 1902.)—Recent determinations of the densities of these gases show that they belong to the series $H \times 7n$, which includes nitrogen, in a table of the elements arranged with atomic weights in multiple proportion, n being for argon 3, for krypton 6, and for xenon 9. Since there is considerable difficulty in purifying neon, and its density is abnormal, the atomic weight is taken as $H \times 7$, n being one, the author considering that 9·96, the density found by Ramsay and Travers, makes the atomic weight too high. [See also Abstract No. 2415 (1901).] S. R.

1571. *Micro-Crystalline Structure of Platinum.* **T. Andrews.** (Roy. Soc., Proc. 69. pp. 433–435, March 21, 1902.)—The author's examination of the etchings produced on the surface of polished platinum by immersion for a short time in boiling aqua regia shows that the crystalline structure of this metal appears to generally resemble those of gold and silver. The photographs taken, reproductions of which accompany the paper, exhibit clearly both large, or primary, crystal grains and secondary, or very minute, crystals. The primary grains consist of irregular polygons of varying size, the etched indications of the facet junctions being in many cases clearly and sharply defined. The minute crystals are arranged in varied orientations in the mass, but the orientation is generally identical, or on the same plane within the area of each larger crystal grain. The general micro-crystalline structure of platinum is allotriomorphic in character, and is derived from a system of interfering cubes and octahedra, the cubic and hexagonal forms being frequently noticeable. The large, or primary, grains vary from about 0·002 to 0·04 in. in size, and the smaller from about 0·0002 to 0·007 in.; it seems probable, from observations made, that the secondary crystals are each built up of even more minute crystalline particles. From the researches of Liversidge on platinum nuggets, there appears to be considerable identity between the crystalline structure of natural platinum nuggets and that of the ingot employed by the author. T. H. P.

1572. *The Significance of Changing Atomic Volume. II. The Probable Source of the Heat of Chemical Combination.* **T. W. Richards.** (Amer. Acad., Proc. 37. pp. 399–411, Feb., 1902, and Zeitschr. Phys. Chem. 40. pp. 597–610, May 13, 1902.)—It is shown that the relation between heat of chemical action and change in atomic volume, as suggested in a previous paper [see Abstract No. 2430 (1901)], is very close. Taking chlorine as a non-metal with a large coefficient of compressibility, and comparing the heat

of formation of a series of metallic chlorides, with the contraction that occurs, the correspondence appears to indicate the existence of a fundamental relationship between the two phenomena, and the law is formulated that "the work needed for the compression involved in the formation of one solid or liquid by the combination of two others, is approximately proportional to the heat evolved." A hypothetical interpretation of this law is given, which also explains the mechanism of the heat of absorption, adhesion, and change of allotropic form. The evidence obtained is strongly in favour of the hypothesis of compressible atoms, and the far-reaching effects of this theory on many physical, chemical, and astro-physical problems are pointed out.

S. R.

1573. *Union of Hydrogen and Chlorine. The Draper Effect.* **J. W. Mellor** and **W. R. Anderson.** (Chem. Soc., Journ. 81. 82. pp. 414–418, April, 1902.)—The Draper effect consists in the sudden expansion and immediate subsequent return to its original condition of a mixture of equal volumes of hydrogen and chlorine, when acted on by the light from an electric spark. The authors describe the best means of demonstrating this effect, and they find also that hydrogen chloride is formed during the phenomenon, which is only produced by the luminous rays of light. The effect occurs with mixtures of approximately equal volumes of hydrogen and chlorine, but not with the latter alone, or when mixed with steam, air, nitrogen, carbon dioxide, carbon monoxide, or methane. The amount of combination taking place between the two gases depends, not only upon the number, but also upon the intensity, of the sparks, and when the effect reaches a certain magnitude depending on the "sensibility" of the gas, explosion occurs, and this appears to be a large Draper effect. The motion of the index fluid which occurs when the insolation vessel of Bunsen and Roscoe's actinometer is exposed to a flash of light, appears to be brought about by some disturbance in the gas attending chemical combination.

T. H. P.

1574. *Invisible Liquid-layers. Surface-tension of Liquid Precipitates.* **G. Quincke.** (Ann. d. Physik, 7. 3. pp. 631–682, March, 1902.)—The ferrocyanides of copper, cobalt, nickel, and iron are first obtained as supersaturated solutions, from which liquid oily precipitates are thrown out periodically, and solidify; the liquid states persists 1·2 seconds in the case of iron or nickel, 15 seconds in the case of cobalt, and 1·30 seconds in the case of copper. Solidification may take place before the liquid has reached a state of equilibrium; this is least likely to occur if the surface-tension of the liquid is high and the viscosity low.

Similar liquid precipitates are formed in solutions of sodium or potassium silicate, with salts of copper, nickel, iron, and manganese, with calcium chloride and ammonia, and with acids, the liquid state persisting 0·3 to 0·5 seconds in the case of iron, 15–20 seconds in the case of manganese, 30 seconds in the case of copper, 120 seconds in the case of cobalt, and indefinitely in the case of hydrochloric acid.

T. M. L.

1575. *Equilibrium in the System Sodium Carbonate, Ethyl Alcohol, and Water.* **C. H. Ketner.** (Zeitschr. Phys. Chem. 39. pp. 641–690, March 18, 1902. Abstract from Inaugural Dissertation, Leiden, 1901.)—An equilibrium study of the formation of two layers in mixtures of ethyl alcohol and water by the addition of sodium carbonate (compare De Bruyn) [see Abstract No. 1122 (1900)], the behaviour of the gaseous-phase (Schreinemakers) [see Abstract No. 1171 (1902)] being also considered.

T. M. L.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

1576. *Steam Engine Governors and Parallel Running of Alternators.* **C. F. Guilbert.** (Soc. Int. Élect., Bull. 2. pp. 281–327, April, 1902.)—This paper is a *résumé* of the conclusions arrived at by a commission of inquiry appointed to discuss the whole question of the parallel running of alternators as affected by the engine governors (understanding by this term mechanical governors, those worked either wholly or in part by electrical means being outside the scope of the inquiry). Thirteen points were laid down for discussion, each of which is treated separately in this paper. Taking them in order, these points, with the conclusions arrived at, are briefly as follows :—

(1) The desirability of defining by a special coefficient $K = (N_0 - N_{max})/N_0$ (N_0 and N_{max} = angular velocities at no load and full load respectively) the controlling power of the governor. This coefficient, or some other similar function of the speeds, has been called the *coefficient of isochronism*. Inasmuch, however, as isochronism is a most undesirable condition for parallel running, the term is inappropriate, and "governor coefficient" is proposed as a better name. The curve representing mean angular speeds as a function of the load is of great importance ; this is really the mean between two nearly parallel curves, the difference of whose ordinates is called the *stability ;* the actual mean speed for any load may oscillate between the two limits, this oscillation being due, amongst other things, to variations in friction and to play in bearings and gear-teeth. For a given load the "stability" of the governor ought, for reasons which are explained, to be greater than the difference between the maximum and minimum instantaneous speeds during one revolution. This point is discussed, and it is shown that, for the same stability, the loads taken by different sets (supposed of equal capacity) will tend towards equality as the curves referred to are more inclined towards the axis of load. (2) and (3). Various engine-makers and central station engineers were asked to obtain experimentally curves of mean engine speed as a function of load, some of which are reproduced. Pressure in the steam chests, in one typical case, was maintained constant by means of the throttle valve ; the curve is nearly a straight line, slightly convex to the origin. The drop is about 5 per cent. between no load and full, the load being that between the alternator terminals. If i.h.p. is plotted as abscissa, the convexity is increased. It is desirable, but not absolutely necessary, that the drop in speed should be proportional to the load ; the possible difference in the load taken by two identical sets in parallel is then constant for all loads. The form of curve giving a difference of load *proportional* to the load is that which is convex to the origin ; curves with a point of inflexion and a tangent nearly horizontal are quite impossible for satisfactory parallel running. (4) and (5) The necessity for a considerable "governor coefficient" for parallel working necessitates a special compensation arrangement to maintain the frequency constant. Three such devices are described. One consists of a weight movable either by hand or from the switchboard by means of a small electromotor, which varies the effort which the governor must exert in order to come into action ; or the effect of the weight

may be altered without the necessity for displacing it, by means of the current in a solenoid. The second way is to act on the admission valve of the engine so as to vary the pressure at the steam ports as the load varies. The third method is to use some automatic regulator, such as the Denis compensator, employed by some engine-builders in Paris. The two first methods, while giving the necessary variation of speed, are not always sufficient to maintain it constant ; in such a case, a method devised by Picou has been used, by which a bye-pass with an easily regulated valve is used to shunt the steam admitted to a cylinder. (6) *What is the best type of governor?* Theoretically any form of governor can give a required percentage drop, but practical considerations of dimensions may make one system preferable to another. Quick-acting governors, in which centrifugal force is counterbalanced by springs, are best for parallel running ; the possibility of modifying the range, &c., when in place is also an important consideration, and spring governors or those which make use of an inclined plane lend themselves easily to this. (7) *Governor oscillations.* The period of these ought not to coincide with the period of oscillation of the flywheel, if dangerous hunting is to be avoided. With spring governors the period is generally very short, and can easily be calculated. (8) *Method of damping oscillations.* Short-period oscillations, such as, *e.g.*, those depending solely on the governor, can be damped by a dashpot ; the damping need not be considerable, as friction alone will do nearly all that is required. Long-period oscillations require very powerful damping ; but here a curious effect comes in, that if the orifices in the dashpot piston are adjusted to give the best effect for oscillations of long period, the resulting damping for short-period oscillations will be exaggerated. A remedy for this is to have a dashpot provided with valves which relieve the pressure of the oil when this exceeds a certain limit. [For a description of this device see Abstract No. 1175 (1900).] (9) Governors ought to be of short-period of oscillation, and, to avoid resonance, the various oscillation periods of the plant ought to be different. (10) *The influence of multiple expansion on governor oscillations.* When, as is generally the case, the governor controls the admission to the high-pressure cylinder only, its rapidity of action is diminished by multiple expansion—a condition prejudicial to good parallel working ; and the tendency to oscillations is also increased. When the governor acts on the different cylinders, this tendency is less marked. (11) *Oscillations of long period.* These are given rise to by variation in the existing torque under certain states of load and by somewhat undefined conditions of the governor, particularly excessive damping. In the case of two alternators in parallel, they can be produced by a want of balance of power between the two machines owing to lack of simultaneity in the action of the governors. Long-period oscillations can be reduced (1) by increasing the "governor coefficient," (2) by reducing the distance between the two limiting curves which represent mean speed as a function of load, and (3) by increasing the power of the governor. If the alternator drives the engine, however, these oscillations may reappear. (12) and (13) deal with the best way of governing several alternators running in parallel. Should each set have its own governor, as is the usual practice, or would it be better to regulate the speed of the whole system by a single governor (*a*) acting either on one only of the engines, the governors of the others only serving in case of accident, or (*b*) acting simultaneously on the admission of all the engines? The first method (each plant separately governed) demands that the governors should be very sensitive and should have practically the same percentage drop at full load ; but in practice it is found possible even with

different types of governor to obtain satisfactory results. The disadvantage of this method is that the load comes on or off all the machines simultaneously. **Rateau** proposes to use governors with large percentage drop in combination with Denis compensators; these would be adjusted for the different machines to speeds varying slightly the one from the other. Thus, in the case of four machines running at a speed of about 100, the compensators might be set at 102, 101, 100, and 99 revolutions respectively. Thus there would never under normal conditions be more than one machine running at reduced load; the others would be either fully loaded, or would be taking no load and would of course then be shut down. The second solution (one governor controlling the whole of the alternators running in parallel by regulating the admission of its own engine) may do well enough where the variation is small, as on lighting circuits. Where, however, the variations might exceed the capacity of the controlling machine, serious dangers might be introduced. Against this there is the great advantage that all the other sets are acting under the best conditions economically. With asynchronous alternators this method would be the natural one to employ, if the control were effected by a synchronous alternator. The third method, while electrically leaving little to be desired, is mechanically very difficult to realise. [The memoirs or notes on which this report has been based are appended to the report. They are written by **Blondel, Rateau, Miet, Guilbert, Van der Stegen, Picou, Vigreux** and **Brillié**, and **Chevrier**, and the thirteen points enumerated in the report are discussed at some length.] B. P. S.

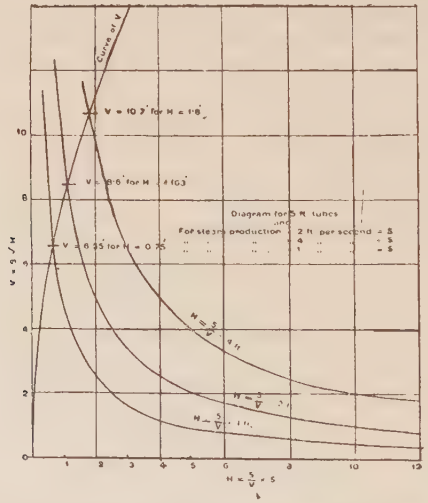
1577. *Lubrication and Formation of Bearing Surfaces.* **J. Dewrance.** (Mech. Eng. 9. pp. 378–382, March 22, 1902.)—The film of oil between a shaft and its bearing is under a pressure corresponding to the load on the bearing and is drawn in against that pressure by the shaft forming what may be regarded as an adhesive pump; it does not seem possible that the velocity of the oil and its adhesion to the shaft can produce a sufficient pressure per sq. in. to support a heavy load, but the fact may be verified by drilling a hole in the bearing and attaching a pressure gauge; in some experiments by the author a pressure of over 2,000 lbs. per sq. in. has been realised in this way. The author gives diagrams of various forms of bearings; for slide blocks he recommends that the surfaces should not have channels cut in them, but that each end of the block should be slightly eased so as to form an inclined plane. In addition to the ordinary rule that the oil to a bearing should be supplied at places where the load is not supported, and that beyond such places the surface of the bearing should gradually incline towards the shaft, the author states that there should be no holes or channels by which the oil may escape from between the surfaces where the load is supported. After a description of the casting of white metal bearings, the author gives the following method of preparing the surface as an alternative to scraping: The bearing is put together and bored out 0·01 in. smaller than the shaft; a mandrel slightly taper at one end and true size at the other is then forced through by means of a hydraulic press; it only remains to form the slightly inclined planes by means of a scraper. The bearing produced is stated to have a surface like a mirror and to be superior to anything that can be produced by careful scraping. H. R. C.

1578. *Relative Positions of Feed and Check Valves, &c.* **W. Kavanagh.** (Power, N.Y. 22. pp. 17–18, May, 1902.)—Some practical considerations are advanced to show that there should be a feed valve on both sides of the

check valve, to facilitate examination and adjustment of the latter. The author also concludes, from reasoning and experiment, that it is better to have the pressure acting above valve discs than under them. F. J. R.

1579. *Circulation in Water-tube Boilers.* **W. H. Booth.** (Elect. Rev. 50. pp. 539–541, April 4, 1902.)—Taking as an example a small tube boiler with nearly vertical tubes averaging 5 ft. in length and $1\frac{1}{4}$ in. inside diameter, evaporating 600 lbs. of water per hour per sq. ft. of grate area, or 13·33 lbs. per superficial foot of tube surface, this is practically equal to 26 lbs. of water per tube per hour, or 0·0072 lb. per second. The water contents of the tube being 2·6 lbs. or 0·0426 cubic ft., the tube will be emptied of $\frac{1}{360}$ of its contents, or $\frac{1}{6}$ in. of its length per second. The volume of the steam formed at 200 lbs. pressure absolute, will be 0·0163 cubic ft. per second, occupying about 23 in. length of tube—so that nearly half the length of tube is filled with steam each second, and must be replaced with water. Moreover, the steam carries up the water in front of it into the steam space.

Taking V as the velocity of flow $= 8\sqrt{H}$; H being the head of water represented by the space occupied by the steam, which latter is represented by S, the author constructs the accompanying diagram, giving three curves


Curve of V
V = 10·7 for H = 1·8
V = 8·6 for H = 1·0·3
V = 6·25 for H = 0·75
Diagram for 5 ft. tubes
For steam production 2 ft. per second = 5
4 " " = 5
1 " " = 5
V = 8 √H
H = 5/V = 1 ft.
H = 5/V = 2 ft.
H = 5/V = 4 ft.
H = 5/V = 5

for H representing the production of 1 ft., 2 ft., and 4 ft. per second, length of steam plugs in tube. The theoretical velocity of circulation for each case is given by the intersection of these curves with the curve of velocity. The diagram is for tubes of 5 ft. in length, and the evaporation is stated in linear feet of tube occupied by steam per second.

The author estimates the quantity of water, the flow of which should be provided for in such boilers, and shows that the downcomers usually provided are inadequate in area. For flatly inclined or comparatively horizontal tube boilers with larger tubes the case is slightly different, but, taking the Belleville boiler, the author shows the inherent defects in its design from this point of view of water circulation, and considers it "absolutely dangerous and unscientific unless provided with mechanically propelled circulation so certain and positive as to compel a sufficiency of water to pass through the tubes," jointly and severally. F. J. R.

1580. *New Steam Engine Valve-Gears.* **H. Dubbel.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1713-1715, Nov. 30, 1901.)—The paper deals with gears for large horizontal engines. A so-called semi-positive Corliss gear is described, in which the variable cut-off arrangement is novel. Only one eccentric is employed, but the admission valves have superimposed on the motion derived in the usual manner from the eccentric, a motion derived from half-way down the eccentric rod and transmitted through a link-motion controlled by the governor. A positive Corliss on somewhat similar lines has the admission valves driven off a subsidiary eccentric mounted half-way down the main eccentric rod. The position of the sheaf of the subsidiary eccentric is controlled by the governor by means of a slot gear, in a similar manner to the ordinary shaft-governor method. A piston type of drop valve, with small clearance in the ports, &c., is described. This motion is sliding, not bedding, thus avoiding the necessity of dashpots. R. C. R.

1581. *The Scott-Elliot Furnace Equipment.* (Engineering, 73. pp. 484–485, April 11, 1902.)—A horizontal tube which is doubled back upon itself to form a flat spiral is embedded in the brick lining or walls of the furnace, generally on both sides and end. Steam from an injector carrying a small quantity of oil is passed into the lowest tier of the tube spiral, and issues from a number of nozzles or jets in the topmost tier—the jets being directed over the fire surface. It is supposed that the tube spiral becomes red-hot, and that dissociation of the steam takes place, the oxygen then combining with carbon from the oil, as the tube showed no signs of being attacked by the oxygen.

Trials on a Lancashire boiler showed a net gain in efficiency of boiler of from 15 to 21 per cent., and in the case of a Babcock-Wilcox boiler a gain of about 11 per cent., both being cases in which the normal efficiency of the boiler was high. The quantity of oil used per hour in the apparatus was only 1·97 lb. in one instance and 0·8 lb. in another, and under half a gallon in the Babcock-Wilcox case—the steam used in the same apparatus being 110 and 71 lbs. It was noticed that the flame carried farther over the boiler surfaces when the Scott-Elliot apparatus was used, which no doubt ensured an increased rate of evaporation from the boiler surfaces. F. J. R.

1582. *Fuel Value of Residuals.* **C. F. Prichard.** (Power, N.Y. 22. pp. 23–27, May, 1902. Written for the 29th Annual Meeting of the American Gas Light Association.)—The author takes for a standard an American bituminous coal having a heat value (calculated from ultimate analysis) of 14,385 B.Th.U., a theoretical evaporative value of 14·8 lbs. water from and at 212° F., and a commercial value of $3·75 per ton of 2,000 lbs., and compares with it, by analysis and tests, gas coke, coke breeze, coal-gas tar, and water-gas tar, in order to find their relative market values as fuel. These he sums up as follows: Coke per ton, $3·75; breeze per ton, $2·48; coal-gas tar per barrel of 50 gallons, $1·38; water-gas tar per barrel of 50 gallons, $1·39. F. J. R.

1583. *Flash Steam Generators.* **C. F. Ruby.** (Horseless Age, 9. pp. 409–410, April 2, and p. 438, April 9, 1902.)—The superiority of flash boilers for use on steam automobiles is maintained by the writer. He states that iron, or its alloys, is the best material to use, and he gives his reasons for making the statement; the decrease in strength of copper or aluminium under the influence of heat render these otherwise more suitable metals useless for the purpose. He then goes on to say that tubes must ultimately give way to

specially constructed "flasher sections," in which the heat can pass within the metal at a sufficiently rapid rate to equalise their temperature throughout. Various methods of feeding water to these generators are mentioned, including two systems utilising compressed air. The author seems to favour the employment of granulated metal inside the generator, and mentions brazing spelter as having been used. The question of automatic regulation of temperature is then considered, and four possible means are set forth ; that of fitting a device in the hottest part of the generator in such a manner that the fuel feed to the burner is reduced as the temperature increases is evidently most favoured. A. G. N.

GAS AND OIL ENGINES.

1584. *Explosion Engines.* **A. Weber - Sahli.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1571–1572, Nov. 2, 1901.)—The author describes a method of plotting results of tests, which is only applicable to hit-and-miss governed engines for which h.p. = const. × pull at brake × r.p.m. Taking the last two factors as abscissæ and ordinates respectively, an hyperbola corresponding to any given h.p. can be plotted. If, on the chart thus obtained, observed values of "pull" and r.p.m. are plotted, the h.p. corresponding to any "pull" or load on the brake can be accurately estimated. By further plotting the relation of the number of explosions to the brake pull, it is noticed that the early part of this curve is quite straight, and by producing this part backwards we can deduce the power that must be given to the motor for zero explosions—in other words, the friction loss. Then, assuming the friction loss constant at all loads, a h.p.-efficiency curve is easily deduced. Curves from a 2-h.p. gas engine are given, and the steep nature of the efficiency curve emphasises the desirability of always running explosion engines at their highest b.h.p. R. C. R.

1585. *Tests of a Riché Gas Producer.* **G. Briand.** (Génie Civil, 40. pp. 397–398, April 12, 1902.)—Tests on a 10-h.p. engine gave the following figures :—

Fuel.	Sawdust and Shavings.	Sawdust and Shavings.	Sawdust and Shavings.	Belgian Anthracite.	Alrique Anthracite.	Logs of wood 60 per cent. moisture.	Coke.
Mean h.p.	8·84	9·4	9·0	9·0	10·0	10	9·0
Gas per h.p.-hour c.cm.	2·73	2·14	2·32	2·3	2·485	2·73	3·51
Fuel per h.p.-hour kg.	2·07	1·66	1·382	0·547	0·66	2·936	0·737
Mean Calories per c.cm. of gas...	—	—	—	—	1220	1180	950

The author considers that coarse coal will prove the most economical fuel for gas producers. [See also Abstract No. 1908 (1900).] E. H. C.-H.

1586. *Inverted Combustion Producers of Fangé.* **J. Deschamps.** (Génie Civil, 39. pp. 323–324, Sept. 14, 1901.)—A description of a producer suitable for reducing wood to gaseous fuel. The charges of wood are put in at the top of the producer, and the air is forced through the glowing mass from top to bottom. The highest temperature is at the top of the producer, and the gas and cinders leave at the zone of lowest temperature. The cinders are

removed by means of a water-sealed trough. The author considers 2·5–3 kg. of wood as calorifically equivalent to 1 kg. of oil. On a plant feeding two 50-h.p. engines the consumption is 2 kg. of wood per h.p.-hour. The calorific value of the gas is given as 1,050 to 1,080 calories per c.cm. at 15° C. for damp wood; 1,220 to 1,270 for dry wood, while by specially adjusting the feed to increase the proportion of methane, this may be increased to from 1,440 to 1,810. [See also preceding Abstract.] E. H. C.-H.

1587. *Producer Gas and its Use in Engineering.* **F. J. Rowan.** (Inst. Engin. and Shipbuilders, Trans. 45. pp. 27–45, March, 1902.)—The author avoids the usual confusion of applying names to the various gases by including them all under the term "producer," and points out that they vary comparatively little in composition. The objection against producers that heat is lost in combustion is founded on the false theory that all the carbon present is capable of yielding its full amount of heat when converted into CO_2. An example based on L. Bell's analysis is given to illustrate this. In order to utilise the heat derived from cooling the gas, a chemical reaction with steam is brought about, ½ lb. of steam per lb. of coal being the average quantity required. Producers are divided into two classes: (1) Those which send the blast among the fuel in a lateral direction, such as Dowson, Mond, Wilson, &c.; (2) those which introduce the blast vertically, such as the Duff. The blowing area in a Duff grate is given as 1,720 sq. in. as against 160 sq. in. in a similar Wilson producer, thus ensuring a high degree of combustion. Various bases of efficiency are touched upon. The Duff producer shows an efficiency of 81 per cent. on D. Clerk's basis (Min. Proc. Inst. C.E. vol. lxxxiv.), which states that with pure carbon and air alone a perfect producer would give a mixture of 1 vol. CO and 2 vols. N, leaving at a high temperature. After emphasising the wastefulness of the ordinary furnace, the author considers various applications of producer gas. (1) In steel making, iron puddling, welding, and processes requiring a high temperature, producer gas has won its greatest triumphs. Drawings of suitable producers are given. (2) For reheating iron, forging, &c., the Weardale furnace is very suitable, 1¾ to 2¼ cwts. of coal being required per ton of iron heated. In (3) a usual form of foundry stove is illustrated, and (4) deals with gas-fired boilers, an average of 9·29 lbs. of water evaporated per lb. of coal being obtained. (5) and (6) describe the application of gas to brick kilns and gas retorts. Under the heading Power the following figures occur: "The heating power of producer gas is within the range 144 to 190 B.Th.U. per cubic foot," and "the cost of production, using expensive coal, is about 1d. per 1,000 cubic feet, and using slack, about ½d."

Discussion.—**P. N. Cunningham** had used the commonest dross with good results. **C. G. Norris** gave the following figures for heating plates:—

	Ordinary Coal-fired Furnace.	Weardale Gas-fired Furnace.
Size of Furnace	15′ 6″ × 6′10″	14′ 10″ × 5′ 6″
Lot of plates heated 53 hours	17 tons.	45 tons.
Cost of heating per ton of plates...	4s. 5d.	2s. 2d.

J. F. Maclaren had been using anthracite and coke for producers, and experienced trouble with clinker, and with tar clogging the gas-engine valves. **A. Wilson** considered coke from the south easier to deal with on account of its higher quality. Clinkering was increased if the gas had to be transmitted to a distance necessitating higher pressure. Producers could be shut down

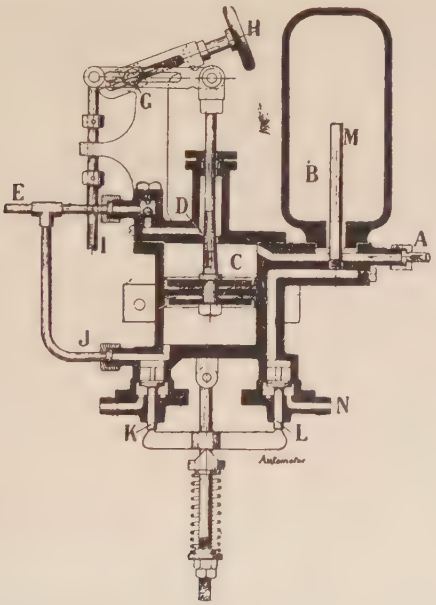
for a day or so. **The President** described an automatic gas-producing regulator. Such regulation is much easier with coke than with bituminous coal. **The Author,** in reply, explained the relation between the heat values of C and CO. The advent of possible coal famines put producers in a more favourable position than formerly. He did not understand Maclaren's trouble with tar. **J. F. Maclaren** explained that he had used Scotch anthracite, and had found that tar arising from coke was worse than that from anthracite. [See also Abstracts Nos. 1173 and 1567 (1901).] R. C. R.

1588. *The Diesel Oil Engine.* (Frank. Inst., Journ. 152. pp. 371–382, Nov., 1901.)—This is a report of a Committee of the Institute. After a careful theoretical consideration of several possible cycles, Diesel concluded that the Carnot cycle (of two isothermal and two adiabatic curves) was the most efficient, and his motor is designed to approximate as nearly as possible to it. He gives four conditions for high economy : (1) The combustion temperature must be obtained, not by combustion but by previous compression ; (2) this is best accomplished by combining the isothermal and adiabatic compression stages of the Carnot cycle into one adiabatic compression stage ; (3) the fuel should be introduced gradually and burned without rise of temperature ; (4) a considerable surplus of air should be present. The motor is of the marine engine type. On one down-stroke the main cylinder is filled with air, which on the up-stroke is compressed adiabatically to 35 atmospheres. At the beginning of the following down-stroke, by means of an auxiliary air-jet, working at about 40 atmospheres, petroleum is injected into and ignited by the red-hot air in the cylinder, the duration of inlet and combustion being regulated by means of a bye-pass valve controlled by the governor. The combustion and expansion take place isothermally. The exhaust is said to show no trace of oil. The results of tests show an effective (b.h.p.) thermal efficiency of—(1) 25·7 per cent. at full and 22·4 per cent. at half load (Schröder), and (2) 25·06 at full and 19·09 at half load (Denton on a 20-h.p. motor). The (i.h.p.) thermal efficiency of an ordinary Otto cycle gas engine is set at 17 to 22 per cent., and of a combined boiler and steam engine at 12 per cent., these figures being subject to reduction for b.h.p. efficiency. The Committee make special comment on the combination of theory and practice embodied in the design of the motor, and on the close approximation of the actual indicator diagrams to the predetermined theoretical diagrams upon which the design was based. An internal combustion motor should have the following features realised in its action : (1) There should be very complete subdivision of the combustible, and thorough mixture with the air ; (2) the combustion air should be raised to a high temperature ; (3) previous vaporisation of the combustible should be avoided, and there should be no separation of light and heavy constituents ; (4) the combustible should not come in contact with cold walls of the cylinders ; (5) there should be no previous mixture of the combustible with more or less cold air ; (6) combustion should be independent of the velocity of propagation of flame ; (7) the pressure should be raised as high as possible before combustion. The extent to which these theoretical features have been attained in the Diesel motor are then enumerated.

On the strength of this report Herr Diesel was awarded the Elliott-Cresson medal. [See also Abstract No. 940 (1901).] R. C. R.

AUTOMOBILISM.[1]

1589. *Creek Street Company's Light Steam Van.* (Automotor Journal, 7. pp. 53–54, April 26, 1902.)—A light steam van by the Creek Street Company of Deptford has a paraffin heated coil boiler. The three-cylinder vertical engine with cam operated valves drives a pair of force pumps, one for water and one for paraffin. The supply of paraffin is regulated by the boiler pressure. The diagram shows the action of the regulator. Water enters the pipe A. The pressure of the feed-water is kept constant on the upper side of the piston and in the air chamber B by means of the spring holding the valve L on its seat, the feed-pump delivering slightly more than the maximum quantity at any time required. This pressure remains constant, in consequence of the valve L being held on its seat by the spring shown, the valve



allowing any water to flow back to the tank if the pressure rises above the normal. The pressure in the chamber C forces the piston downwards, and at the same time keeps open the orifice between the piston rod F and the rod D. This downward action causes the burner to open wider by the upward action of the rod A. If the boiler pressure rises above a certain point it operates upon the lower side of the piston, forcing it upwards, thus cutting off the burner and ultimately closing the free passage of water through D. If the boiler pressure rises considerably it opens the valve K, which is normally held on its seat by the same spring which holds the valve L, and the water in the boiler is allowed to run out. By this means the position of the piston in the chamber C depends upon the pressure in the boiler. The relative heat of the burner to the quantity of water fed into the boiler is regulatable by the handle wheel H. M. O'G.

[1] Electric Automobiles are described in the Section dealing with Electric Traction.

1590. *Lehmbek Spirit Motor Ploughing Locomotive.* (Motorwagen, 5. pp. 96–97, March 31, 1902.)—This vehicle is designed for travelling over heavy ground with loaded trailers. The wheels are of the well-known road locomotive type, the driving wheels, which are situated at the rear of the vehicle, being shod with iron cross-bars. The motor is arranged at the front of the vehicle, with its shaft along the axis, and transmits power through double bevel and spur wheels to a counter-shaft, which is geared to the rear axle through chains. The motor shaft projects in front of the vehicle, and is fitted with a pulley, from which power is taken for driving a plough. The water tank is situated directly above the rear axle, so as to increase the adhesion of the driving wheels. J. G.

1591. *The Brush Petrol Car.* (Automotor Journal, 7. pp. 37–39, April 26, 1902.)—The Brush car is built on a main rectangular framework of wood and steel, the mechanism being carried from an under framework. The Abeille type motor of 10 h.p. has the two cylinders cast in one piece, and the induction valves placed over the exhaust valves so as to be removable without taking off the supply pipe from the carburettor. The circulating pump is gear-driven. The usual ignition is the Dawson magneto. M. O'G.

1592. *Packard Gasoline Car.* (Scientific American, 86. pp. 146–147, March 1, 1902.)—This vehicle has a rectangular channel steel underframe sprung from the front axle by double-cross plate springs, and from the back axle by elliptic side plate springs, and the mechanism of the vehicle is directly attached to this underframe, there being no axle connecting frame, so common on American cars. The engine is of the single-cylinder horizontal type mounted towards the back end of the frame and with crank-shaft lying across the frame somewhat behind the centre of its length. A cast-iron cylinder and copper water-jacket are employed. The carburetior is of the float-feed spraying type. The ignition is high-tension electric, and the engine is governed by automatically varying the point of firing. A heavy flywheel is mounted at one end of the crank-shaft, and from this end the power is transmitted through a friction clutch and a spring-drive to the upper shaft of the change-speed gear ; this shaft is in line with the crank-shaft, and on it are mounted four spur pinions in pairs, which may be engaged with corresponding fixed wheels on a lower shaft. This gear provides three speeds forward and one reverse, controlled by one lever. The power is finally transmitted from the second motion shaft of the change gear to the live rear axle by a single roller chain. Suitable radius rods are provided for maintaining the correct distance for the chain centres. Wheel steering, acting through a worm and sector gear, is employed. C. R. D'E.

1593. *Roller Bearings for Automobiles.* **Hele-Shaw.** (Automobile Club Notes and Notices, 3. pp. 92–96, March, 1902. Paper read before the Automobile Club.)—After some general remarks on the action and advantages of roller bearings, the author summarises as follows the difficulties which are encountered in their design and construction : (1) The concentration of the load on a very small bearing surface ; (2) the difficulty and expense of obtaining rollers truly cylindrical and circular ; (3) the friction between the rollers themselves ; (4) the difficulty of adjustment ; (5) the tendency to twisting when worn ; (6) the provision for end thrust ; (7) the occurrence of hammer blow and shocks, with motor cars, when worn. No. (1) is minimised by efficient hardening, and as this always causes some deformation, subsequent

grinding, an expensive process, is required to obtain the best results. Parallel roller bearings being incapable of adjustment, this difficulty has been met by the use of conical rollers, which may also be so designed as to take up the end thrust which has to be provided for in the case of motor cars. The author describes several methods of caging designed to obviate both (3) and (5). In conclusion he observes that he has not considered the amount of power that may be saved by the use of roller bearings, since their advantages in this respect are undisputed, and the only obstacle to their general introduction is the difficulty of obtaining an efficient form of bearing which can be cheaply constructed. *Discussion.*—**W. Beaumont** believed that it was fairly well established that the advantages of roller bearings diminished with increasing speed, which he ascribed to the friction of the rollers in the guides. G. W. DE T.

1594. *Roller Bearings for Automobiles.* **G. W. de Tunzelmann.** (Automobile Notes and Notices, 3. p. 278, July 10, 1902.)—In confirmation of Beaumont's suggestion [see preceding Abstract] that the falling-off in the advantage of roller bearings with increasing speed is mainly due to the increased friction of the rollers in their guides, the author quotes tests made by Messrs. Whiteley and Sons, Prospect Iron Works, Lockwood, on some bearings with hollow rollers kept apart by internal pins, a method of guiding which minimises this braking effect. The results of the tests made on bearings 1¾ in. diameter, and 3½ in. long, are as follows:—

Total weight put on.....	245	848	1,463	2,352 lbs.
Weight per in. run of bearing...	35	121	209	336 „
Weight per axial sq. in. of bearing	20	69	120	192 „
Speed and power taken :—				
175 revolutions per minute.....	62	96	160	300 watts
280 „ „	75	162	225	450 „
570 „ „	141	287	481	— „

Showing that, in this case, the advantage increases, instead of decreasing, with increasing speed. M. O'G.

1595. *Simms War Motor Car.* (Automotor Journal, 7. pp. 15–16, April 19, 1902.)—This is a car designed to support a load of 12 tons, having an overall frame dimension of 17 ft. × 6 ft. 2 in. The 12-h.p. motor of Carnstatt-Daimler type drives the car at 1½, 3, 5, or 9 miles an hour. The weight of the car itself is 5½ tons, the armature is 6 mm. Vicars steel, and its length from point to point of the rams is 28 ft. Its width is 8 ft. and height 10 ft. The armature swings independently of the frame. The gun equipment consists of two pompoms and two quick-firing maxims, with 10,000 rounds of ammunition. Plans and sections of the car are given. M. O'G.

1596. *Determination of the Path of Air-Ships.* **H. Deslandres.** (Comptes Rendus, 134. pp. 344–346, Feb. 10, 1902.)—The author criticises the method of Armengaud as inaccurate, and favours the determination by means of photographs. A camera is used in conjunction with a chronometer, which automatically registers the exact moment at which an exposure is made. To facilitate calculations, two consecutive images may be taken on the same plate. Diagrams of the path of Santos-Dumont's air-ship, as traced by the author, are given. [See also Abstracts Nos. 391 and 551 (1902).] E. H. C.-H.

GENERAL ELECTRICAL ENGINEERING.

1597. *Insulation of Electric Supply Cables.* **P. Charpentier.** (Soc. Int. Élect., Bull. 2. pp. 204–234, March, 1902.)—The high-insulation resistance usually required of cable-makers is not in itself of much value; even if the resistance were reduced to one-thousandth of its usual value, the loss of energy by leakage would be negligible. These high insulations are demanded merely as a guarantee of the quality of the cable, but they should not enter into the specification of a cable, for an insulation of equal durability and equal strength against rupture might have far less resistance and be equally serviceable in practice. The insulation of a cable should satisfy the three conditions of (1) a definite maximum leakage, (2) strength against rupture, and (3) durability. As a measure of the resistance should be taken that observed when the current has become practically constant, not that after one minute's electrification. The ratio of these two resistances varies largely in different sizes of cables, and for continuous currents the former only has any practical value. The strength against rupture bears very little relation to the insulation resistance. It depends really on the uniformity of the materials used and the care exercised in manufacture, for over a small surface, the thickness of insulation for a given strength is often only about one-tenth that required in a long cable. It is not advisable to test the whole cable, as is usually done, at a pressure double the working pressure, as such a test may permanently injure the insulation. The better test is to measure the pressure of rupture over a length of the cable and allow a factor of safety of 4 to 5. The author suggests that cables could be cheapened by substituting for the armouring, lead sheathing, and for a dielectric of high-insulation resistance, a thick layer of moderately insulating material sufficiently strong to withstand handling and laying, which could be applied to the bare copper as the cable was laid. G. H. B.

1598. *Cable Deterioration.* **C. Formenti.** (Elettricista, Rome, 11. pp. 99–100, April, 1902.)—The author observed the deterioration of the return wire of an earth cable composed of twenty strands of galvanised electrolytic copper wire, covered first with cotton and then with a composite rubber coating. Soon after the cable was put down small vesicles of liquid appeared in the rubber coating, and these increased in size till they burst. By analysis of the rubber and also of the contents of the vesicles, it was shown that the rubber envelope, and not the soil, furnished the materials for the contents of the liquid. By heating up the rubber with water a quite similar solution to that of the vesicles was obtained. It appears, therefore, that the rubber coating acted as a semi-permeable membrane, and admitted water, which dissolved out part of the contents of the rubber. The current then set up electrolysis in the solution so obtained. The deterioration described was prevented by coating the cable with a non-permeable substance such as coal-tar. D. H. J.

1599. *Cranes in German Dockyards.* (Engineer, 93. pp. 410, 414, and 418, April 25, 1902.)—This article contains a description and drawing showing the general construction of various dockyard cranes, made by the Benrather Machine Company. The latest and largest of these has been constructed for the Howaldtswerke at Kiel, and lifts a working load of 150 tons at a

radius of 65 ft., and of 50 tons at a radius of 134 ft., the gantry rails being 154 ft. above the level of the ground. It is worked by three-phase induction motors. It is very similar in outline to the one built by the same firm in 1889 for the dockyard at Bremerhaven, which is worked by direct-current motors. The principal outlines of the design in both these cranes are fully described.
W. H. S.

1600. *Electric Pumping Plant.* (Engineer, 93. p. 355, April 11, 1902.)—This plant, which is said to be the largest of its kind in this country, has been put down by Scott and Mountain at the Eldon Colliery, Durham. The generating plant consists of a 220-kw. steam-driven dynamo, supplying current at 500 volts to motors at the bottom of a shaft, 150 yards deep. The motors drive the pumps by cotton ropes ; the motor speed is 450 r.p.m. ; the pump speed 27 r.p.m., and each pump delivers 500 gallons per minute against a head of about 400 ft. On test the following figures were obtained on full load. The pumps delivered 64·8 gallons of water against a head of 400 ft. per lb. of coal used in the boilers. The ratio between the output at the dynamo terminals and the h.p. in the water pumped, the pumps being at a distance of 1,000 yards from the generator, was 72·7 per cent. The efficiency of the pumps alone was found to be 85 per cent., and of the motors 91 per cent.
W. H. S.

REFERENCES.

1601. *Calculation of the Capacity of Accumulators at varying Discharge Rates.* **J. Izart.** (Ind. Élect. 11. pp. 153–154, April 10, 1902.)—The paper describes a graphic method, and is illustrated with curves. E. J. W.

1602. *Electric Storage Batteries.* **A. Reuterdahl.** (Cassier, 21. pp. 489–502, April, 1902.)

1603. *Electric Foundry Cranes.* **A. Krebs.** (Elekt. Runds. 19. pp. 129–130, March 15, 1902.)—The article contains sketches of different types of crane and lifting tackle, employed in foundry work, and operated electrically. W. H. S.

1604. *Coal-cutting by Machinery.* **E. K. Scott.** (Inst. Civil Engin., Proc. 144. pp. 247–268, 1901.)—A record with descriptive woodcuts of the various types of percussive, wheel, and rotary bar coal-cutters that have been put in use with the results of their working. The paper contains too much detail to be abstracted.
Ll. B. A.

1605. *Electricity in Mountain Mines.* **F. W. Brady.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 281–291 ; Discussion, pp. 402–406, 1901.)—The author describes plant installed in the mountains of California and Colorado, with special reference to methods of constructing plant so that the parts could be brought into place by mule or human transport. Ll. B. A.

1606. *Use of Electricity in Belgian Coal-mines.* **Halleux.** (Soc. Belge. Élect., Bull. 18. pp. 269–277 ; Discussion, pp. 277–280, 1901.)—The author describes the present position of the use of electricity in the coal-mines of Belgium. About 3,000 h.p. is now so transmitted in Belgium. The paper is chiefly interesting in so far as it expresses generally the attitude of Belgian engineers towards electrical work in its various branches. Ll. B. A.

GENERATORS, MOTORS, AND TRANSFORMERS.

1607. *Magnetic Reaction of Dynamo Armatures.* **V. Karpen.** (Comptes Rendus, 134. pp. 827–829, April 14, 1902.)—The author points out that in calculating the magnetic reaction of the armature it must be remembered that the reluctance is greater in the direction of the pre-existing flux than in the opposite direction. The transverse ampere turns have a maximum effect near the bend of the curve of magnetisation of the pole-pieces and armature. Magnetic leakage diminishes the useful flux and increases the demagnetising flux. He gives a table of experimental results to show that the demagnetising effect of the armature has a maximum for a certain value of the excitation.

R. B. R.

1608. *Armature Winding Diagrams.* **D. Robertson.** (Inst. Elect. Engin., Journ. 31. pp. 949-970, April, 1902.)—The author shows how to construct winding tables, circuit tables, and current diagrams for a number of different windings. The current diagrams are particularly useful in studying the changes in the distribution of the current during commutation or with different widths or arrangements of brushes. R. B. R.

1609. *Commutation.* **Boy de la Tour.** (Ind. Élect. 11. pp. 79–83, Feb. 25; and pp. 107–112, March 10, 1902.)—The author of this paper considers that the usual method of attacking the problem of commutation is unfortunate; the introduction of the term $L di/dt$ really complicates the question quite unnecessarily. Starting from elementary considerations, and taking first the case in which the brush only presses on two commutator bars simultaneously, it is shown that the self-induction of the coils short-circuited by the brushes is practically negligible, and that these coils move in a constant field, and are therefore the seat of an invariable electro-motive force. This granted, equations are deduced which give the value of the current at each instant, and the condition for sparkless running is found to be $R_1 i_1 \geq e + I(R_a + 2R + 2R_{II})$ where R_I, R_{II} are the contact resistances of the brushes on the two commutator bars (the former being that of the leading bar); i_1 is the current passing between the brush and the leading bar at the moment of commutation; R_a is the ohmic resistance of the short-circuited coil; I is one-half of the normal current of the machine, e the e.m.f. generated in the coil, R the resistance of the connection between the winding and each commutator bar. The e.m.f. $i_1 R_1$ is the limiting tension which will admit of good sparkless running. The equation shows that, keeping the output the same, reduction of the speed by diminishing the value of e lessens the sparking, a deduction which is supported by experience; it also shows the importance of keeping the term $R_a + 2R + 2R_{II}$ as small as possible, *i.e.*, of reducing the resistance of the connections between the commutator bars and the windings. It is suggested that absolutely sparkless commutation might be obtained without shifting the brushes if small auxiliary poles were provided close to the latter, these poles being excited in series with the armature; the e.m.f. e could thus be annulled for any value of the current. The case is then discussed in which the brushes press upon three commutator bars at the same time, *i.e.*, the width of the brush exceeds that of bar *plus* insulation, and a similar equation is arrived at

as the condition for sparkless running. The permissible limit for iR is given as about 2·5 volts. The latter part of the paper is taken up with a discussion of the general question of sparkless commutation, in which it is shown how all the phenomena observed can be explained by means of the equations; and it is further shown how, in the case of a machine which sparks excessively, the true cause may be assigned. By means of an exploring coil the strength of the field in which the short-circuited coils are moving can be measured, and the equations given can then be made use of to determine whether the values of the tension between the brushes and the commutator bars are satisfactory. If the values found are not excessive the fault is not strictly one of commutation, but lies either in the condition of the commutator, the action of the brush-holders, or the design of the winding. The paper concludes with two numerical examples worked out at length. The article is illustrated by diagrams and curves. B. P. S.

1610. *Self-exciting Alternators.* **M. Latour.** (Écl. Électr. 31. pp. 50–59, April 12, 1902.)—This paper contains a detailed account of the theory of the author's self-exciting alternator [see Abstracts Nos. 334, 1235, and 1440 (1902)]. In many respects such an alternator closely resembles an ordinary continuous-current shunt-wound machine. In order to secure synchronous running, the brushes through which the three-phase currents are fed into the high-resistance rotor winding must be given a forward lead, which has to be increased with increasing load. On account of the high resistance of the rotor or field winding, and the consequently small current in this winding, there are no difficulties as regards commutation. When a sudden increase of load takes place the machine drops slightly out of synchronism, and the slip of the rotor reduces the drop which would otherwise take place in the p.d.; by readjusting the brushes synchronism may again be established. The concluding part of the paper is of a controversial nature; the author points out that a self-exciting shunt-wound alternator such as the one described by himself has nothing in common with a form of motor devised about 1890 by Rotten, several examples of which were constructed by Siemens and Halske. In Rotten's motor three-phase currents were fed into the three-phase winding of the stator, and into the continuous-current armature winding of the rotor, which was provided with a commutator and brushes. Each winding gave rise to a rotating field, and the torque was due to the non-coincidence of the fields. By shifting the brushes the stator field could be arranged to be either behind or in advance of the rotor field, and so the motor could be made to run either way; further, the motor could be made to run at varying speeds independently of the frequency of supply—it was essentially an *asynchronous* motor. The thickness of the wire used in the rotor winding was, in Rotten's motor, of the same order as that of the stator winding. In contrast to this arrangement, the author points out that in his own machine the rotor will always start in the direction of the rotating field, no matter what the position of the brushes may be, and that the motor does not attain its normal torque until the speed has become nearly synchronous; further, the rotor winding has a very high resistance. The resistances of the rotor windings used in Rotten's motors would have been burnt out at synchronous speed. A. H.

1611. *Synchronous Reactance.* **F. G. Baum.** (Elect. World and Engineer, 39. p. 724, April 26, 1902.)—The author shows, by a graphical method, that the use of "synchronous reactance" instead of demagnetising effect and leakage reactance in predetermining the drop in an alternator does not generally lead

to any appreciable error. He suggests that instead of determining the "synchronous reactance" from the short-circuit current—a method which generally gives a larger value than that corresponding to a fully excited field—this quantity might be obtained by running the alternator as a synchronous motor, and gradually increasing its excitation until a current of about the same order as at full load is obtained through the armature. The difference between the p.d. and the e.m.f. of the motor then practically gives the reactance e.m.f. A. H.

1612. *Parallel Running of Alternators.* **P. M. Lincoln.** (Frank. Inst., Journ. 153. pp. 241–257, April, 1902.)—In this paper the author discusses the general question of parallel running, which he considers a problem of engine governing pure and simple. Proper division of load depends on the percentage drop of speed between no load and full load; hunting can be reduced by diminishing the motive force, which by synchronising with the pendulum swing may increase the oscillations to a dangerous pitch, and by damping out the oscillations by electrical friction. The first result can be achieved by prolonging the time of response to motion of the governor balls, which can be done by properly designed dashpots [see Abstract No. 1175 (1900)]. The effect of the uneven torque at different points in an engine cycle in causing hunting can be remedied by increasing flywheel power, and by synchronising engines as well as alternators. The damping out of the oscillations can be effected by surrounding the field poles with copper bands, or better, by projecting copper plates under the pole-tips; these are in a better position than the bands round the field poles to generate the necessary eddy currents, as they lie more completely in the resultant field. The paper concludes with a description of the various methods of synchronising in general use, none of which are satisfactory, owing to lack of sensitiveness, and to the fact that no information is given as to which of the two phases which are being compared, is in advance of the other. The author describes a device of his own which is superior in every way to the old methods, and which is a true phase indicator, independent of the two e.m.f.'s whose phase relation it indicates, and showing by the angle between a moving and a fixed pointer on a dial the exact difference of phase, and by the direction of rotation of the moving pointer which e.m.f. is in advance of the other. [See also Abstract No. 1943 (1901).] The device is used by the Niagara Falls Power Company, where by its aid five 5000-h.p. dynamos have been synchronised in three minutes. B. P. S.

1613. *Parallel Running of Alternators.* **H. C. Leake.** (Elect. Rev. 50. pp. 543–544, April 4, and pp. 631–632, April 18, 1902.)—In this paper the author deals with the effect of the cyclical speed variation of a prime mover coupled direct to an alternator upon parallel running, and comes to the conclusion that the usual method of specifying a maximum permissible phase displacement, when the plant is run on a load offering a constant torque, is not justified by theory. He contends that the more rational method of designing the rotating parts would be to proportion them so that what he terms the "characteristic fluctuation of output"—*i.e.*, the periodic variation of output as affected by the periodic variation of torque—should not exceed a certain limit. The author also comes to the conclusion that the statement that parallel running is facilitated by low frequency is unwarranted by theory. The amount of phase displacement usually allowed in prime movers is not more than 2° when the load includes rotary converters; for a load of synchronous motors it may be a little more, and for a non-synchronous load

a still larger displacement is allowed. When two alternators giving the same e.m.f. are running in parallel, the method generally adopted to calculate the maximum cross-current is to obtain the resultant e.m.f. tending to produce this current (by multiplying the e.m.f. of either machine into twice the sine of the maximum phase displacement), and to divide the product by twice the synchronous impedance of one armature. The usual assumption, which is controverted by the author, is that if the rotating parts are so designed (as regards inertia, &c.), that the maximum phase displacement is not exceeded when running on a load with constant torque, then in parallel operation the maximum cross-current will not be exceeded. This assumes something which is untrue, viz., that the maximum phase displacement in parallel is no greater than when running singly on a load of constant torque; nor is the phase displacement necessarily reduced by the interchange of power between alternators in parallel. By a graphical method, using curves in which the abscissæ are the phase-differences between the e.m.f. of the alternator in question and that of the bus-bars, and the ordinates are the two components (phasal and wattless) of the alternator current, and the driving torque, the author shows that if the moment of inertia of the rotating parts of a generator set *exceeds* a certain amount, the actual maximum phase displacement when running in parallel exceeds that when running on a load offering a constant torque. He also shows that there is, for every set, a critical value of the moment of inertia depending on the periodic time of the fluctuation of driving torque, so that the conditions are improved either by reducing or increasing the moment of inertia. B. P. S.

1614. *Synchronous Motor Calculations.* **F. G. Baum.** (Elect. World and Engineer, 39. pp. 861–864, May 17, 1902.)—The author gives an account of a simple graphical method of attacking synchronous motor problems which is practically indentical with that given by Görges and referred to in Abstract No. 1360 (1900). If in the vector diagram the p.d. across the generator or motor terminals be supposed to remain constant while the excitation of the machine is varied—the power remaining constant—then the extremity of the e.m.f. vector moves along a straight line. A. H.

1615. *Theory of Asynchronous Motors.* **Colard.** (Assoc. Ing. Él. Liège, Bull. 2. pp. 8–19, Jan., 1902.)—This paper contains a mathematical investigation of the general theory of asynchronous motors. The writer imagines a mass of iron of a given thickness, but of indefinite extent in the two other directions, in which a cylindrical hole is pierced, containing a cylinder of iron of slightly smaller diameter. These two masses constitute the stator and rotor respectively. A distribution of currents in sheets on the surfaces of the stator and of the rotor is assumed, whence is deduced (on the assumption that the reluctance of the iron is negligible compared with that of the air-gap), a corresponding distribution of the magnetic flux in the air-gap. Formulæ are then found for the electromotive forces and currents developed, and for the resultant torque, and the results are seen to be interpretable by means of Heyland's diagram. B. P. S.

1616. *Tests of a Multiphase Motor.* **E. Ziehl.** (Elektrotechn. Zeitschr. 23. pp. 236–239, March 20, 1902.)—The paper describes a series of tests made on a four-pole motor for a normal output of 10 h.p. on a 190 volt 50 ∿ three-phase motor, designed by the author for the Schwartzkopff Company. Sections of the motor are given, as well as curves giving efficiency, power-

factor, and slip for different loads, losses when running light at different voltages, and starting torque at different voltages. The efficiency reaches a maximum of 91 per cent. at half load; at full load it is 90 per cent. The power-factor reaches 0·925 with a load of 9·5 h.p. To determine the limiting load on intermittent work for a given temperature limit, a series of time-temperature curves for different loads were taken, as well as cooling curves both running light and standing. From these curves the limiting load under different conditions is determined graphically. Thus while the motor in question could give 14·6 h.p. indefinitely without rising more than 50° C. above the air temperature, if loaded for 20 minutes to 17·5 h.p. it would require to stand for 40 minutes in order to remain below the same limiting temperature. A. E. L.

1617. *Transformer Regulation on Inductive Loads.* **P. C. Butte.** (Journal of Electricity, S.F. 12. pp. 99–100, May, 1902.)—A practical formula is given for the p.d. drop across the secondary of a transformer on an inductive load. Experiments were made and curves are shown illustrating the effects of an inductive load on the p.d. between the terminals of the secondaries of a single-phase transformer wound for three-wire distribution. The curious effect was observed that, when one side had an inductive load and the other side was on open circuit, then there was a gradual rise of the p.d. on the unloaded side as the inductive load (power-factor 0·7) was increased. This was probably due to the magnetic leakage from the windings of the loaded secondary. A. R.

REFERENCES.

1618. *Measurement of Armature Resistance.* **A. Wettler.** (Elektrotechn. Zeitschr. 23. pp. 8–10, Jan. 2, 1902.)—The paper gives formulæ for the calculation of the armature resistance of multo-polar direct-current generators derived from a knowledge of the type of winding. W. W. H. G.

1619. *Formulæ for Regular Armature Windings.* **D. Robertson.** (Inst. Elect. Engin., Journ. 31. pp. 933–948, April, 1902.)—The author works out a number of formulæ for the conditions of re-entrancy, number of re-entrances, and conditions for not clashing, for gramme and drum armatures. R. B. R.

1620. *Induction Motor with Power-factor of Unity.* **A. Heyland.** (Écl. Électr. 30. pp. 419–423, March 22, 1902.)—This is a brief exposition of the principles underlying the construction of the author's motor [see Abstract No. 2475 (1901)], and a comparison with the motors devised by Görges, Latour, and Blondel. A. H.

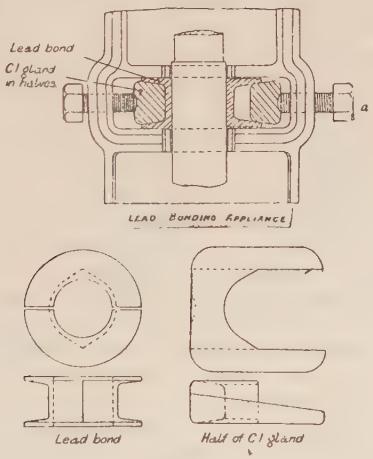
1621. *Tramway Motors.* **Siebert.** (Elektrotechn. Zeitschr. 23. pp. 187–190, March 6, 1902.)—A discussion of various points in the design of traction motors, particularly for large powers, where there is difficulty in keeping the dimensions within reasonable limits. The design adopted by the author for the motors of the Maison Breguet of Paris is illustrated by outline drawings and sections. A. E. L.

1622. *Wagner Single-phase Motors.* **E. S. Pillsbury.** (West. Electn. 29. pp. 318–319, Nov. 16, 1901. Abstract of paper read before the Ohio Electric Light Association at Put-in-Bay, Ohio.)—A discussion of the merits of single-phase distribution, in addition to a description with drawing and diagrams of the Wagner single-phase motors. [See also Abstract No. 346 (1900).] A. E. L.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

1623. *Continuous-Current Mains.* **J. C. A. Ward.** (Inst. Elect. Engin., Journ. 31. pp. 833–852; Discussion, pp. 852–878, April, 1902.)—Ends of cables in manholes where the conductors terminate in thimbles are often sealed by means of lappings of insulating tapes over the socket and back to the lead covering of the cable, but a creeping current will set up across the tape between the bare socket at the end of the conductor and the metal sheathing. Salts due to electrolysis are deposited on the tape, and will be found to have worked under the layers of the tape. The author recommends doing away with tapes and sealing the cable ends in an end-connection box filled with compound, bringing the bare socket through a gland of insulating material such as ebonite, having a corrugated surface. Efficient bonding between the sheathings of the cables terminating at either side of a box is needed. A



single strand of, say, No. 16 gauge copper wire, although sufficient to guard against electrolysis, is inadequate, because it is fused away when, through defects in insulation, heavy currents have passed along the lead sheathing. The disconnection between sections of lead sheathings thereon resulted in faults at the glands owing to the lead having arced on to the box. A wiped joint between the ferrule of the box and the lead sheathing makes an excellent bond and a watertight joint. Efficient bonding should be carried out irrespective of the intentional earthing of any of the poles of the system, as a complication of faults may lead to heavy currents travelling on the lead between points a considerable distance apart. A joint between lead and box may be made without a wiped joint as shown in the accompanying diagram.

One form of an earth-plate used in Glasgow is a 6-ft. length of unpainted cast-iron 4-in. pipe driven vertically into the earth, and connected,

by means of a special bond, to an "earthing" copper conductor in the section boxes. Feeders and networks should be so fused that faulty circuits will be automatically isolated, because 100 yards or more of main may otherwise be completely destroyed. The difficulty is that, in the event of a fault occurring in a certain locality, current flows to this fault from the several feeding-points through several fuses in series, with the result that, instead of fuses blowing in the neighbourhood of the fault, they may be blown at a considerable distance away, thus throwing dead large sections of distributors, the supply to which should not have been interrupted. The rule to be observed is that not more than two feeders shall be connected directly with the distributors laid between them, the connection between these feeders and any others only being made between their respective feeding-points, and not by means of distributors joined at points of intersection of the network between feeding-points. This arrangement avoids the inconvenience of dividing the network into isolated sections and allows out of balance currents to be rectified throughout the general system of network. There are advantages in cast-iron instead of brick manholes—(i) if the system of mains requires earth plates the cast-iron manhole serves the purpose. (ii) Cast iron is both gas and water proof. (iii) The space saved by using cast iron instead of brick provides more room for the fittings inside the box. In most ordinary boxes—(1) the clearance between conductors of opposite polarity is so small that, if once an arc is started between any of these connectors, the whole of the other cables become short-circuited. (2) If there are fuses, the use of set screws or nuts and studs for securing the fuses is objectionable, because the fuses become slack by vibration due to the street traffic or the different expansion of the fuse and the conductor. (3) The use of wood of any description is objectionable, because, however well prepared, it may be in a damp store for months before the box is put into use. (4) The fact that the fuse is in close proximity to the compound is inviting a manhole explosion if the fuse blows. (5) If the lid is secured by bolts, valuable time will be expended in endeavouring to remove it if rust has set in. Cables which rely upon a lead sheathing suffer most from troubles incidental to electrolysis, earth currents, and bad bonding. They should therefore be laid solid, and the metal sheath should be bonded. The usual tests at the manufacturers' works, before the cable has been certified, very often fail to detect defects such as admission of water or pinholes.

A draw-in system has the following objections: (1) If the ducts consist of metal pipes, a fault very often burns a hole in the pipe, besides fusing the conductor solidly on to the pipe. (2) If the cable is withdrawn, the duct is rough at the point where the conductor has arced on to the metal, and this may injure the cable drawn in to replace the faulty one. (3) A draw-in system also ceases to be of much value for distributors, owing to the branch mains. (4) There are water and gas troubles, the gas not only being collected from the subsoil, but also generated by the fault. The troubles with bare strip in earthenware conduits caused by the formation of salts on the negative insulators do not appear where cast-iron duct is used. "Shorts" to the duct may be guarded against by slabs of porcelain laid at short intervals along the bottom of the trough. The longitudinal movement with heat of unstrained strip, if anchored at certain points, is prevented and the strip buckles towards either the top or bottom, or neighbouring conductors. The author concludes that the greatest risks of cables are, in the order of their importance: (*a*) electrolysis; (*b*) mechanical damage; (*c*) defects in manufacture and joints.

M. O'G.

1624. *Conduit Wiring.* **F. Bathurst.** (Elect. Rev. 50. pp. 584–587, April 11, 1902.)—The author advocates the general use of continuously earthing one pole and insulating the other, preferably by drawing a wire into an internally insulated screwed iron tube. The Armorduct system employs a 2¼ in. diameter box which is so cast that, by knocking out one or more sides of the casting with a hammer, it can be used as a one, two, three, or four way outlet box. M. O'G.

1625. *Four-Wire Three-Phase Systems as Applied in Modernising Central Stations.* **P. Junkersfeld.** (West. Electn. 30. pp. 250–251, and p. 258, April 12, 1902. Paper read before the Chicago Electrical Association, April 4, 1902.)—The introduction of the rotary converter and the growth of high-tension transmission, have rendered it possible for crowded districts of a large city to be supplied economically by a low-tension distribution from one large central station and a number of substations with rotaries, installed in addition to the old steam plants, the latter being only worked during the peak of the load, for perhaps one or two months in the year. The cost of running in this way is found to be less than it would be to increase the capacity of the central station and dispense with the steam plant in the substations. Thus, not only is the "scrapping" of old generating stations rendered unnecessary, but the old plant is made, by the addition of the rotary, to answer as well as new apparatus. In the larger cities also it is commercially practicable to supply the tramways from the same source. In smaller cities, however, and scattered areas where single-phase alternating current has been installed, the limitations of the single-phase motor have made it necessary to replace the old single-phase by multiphase generators, and in such cases the four-wire three-phase system of primary distribution offers many advantages. Concisely stated, the advantages of this system of distribution are—(1) two available voltages, for light and power, from the same generator; (2) balancing of single-phase feeders; (3) the use of standard transformers throughout. The author describes fully the arrangements adopted for the various circuits, lighting and power, illustrating his description with plans and diagrams of connections, with special reference to the area in Chicago supplied by the Commonwealth Electric Co. Frequency changing sets are provided in substations, current being generated at 25 periods, and distributed from the substations at 60 periods over the four-wire three-phase system. For many isolated plants, the system (at low potential) could be employed with advantage, the generators delivering at either 440 or 220 volts between phases, for motors, and giving 250 or 125 volts, respectively, between neutral and phase, for lighting. If the isolated plant were situated reasonably near the central station, generating three-phase, there is virtually insurance against an extended shut down owing to accident, as the Company would probably be glad to give temporary help for a few hours, in the hope of obtaining a permanent customer.

Incidentally, the author discusses the question of frequency, and the desirability of compromising with 40 periods as a mean between the frequency of 25 cycles which is preferable for conversion to direct current, and that of 60 cycles which is required for general distribution for lighting, coming to the conclusion that such a compromise would be inadvisable. B. P. S.

1626. *Italian Electric Power Transmission Regulations.* (Elettricità, Milan, 21. pp. 180–183, March 23, 1902.)—These regulations, which have been drawn up by the Italian Electro-Technical Association, include, in addition to

internal wiring rules and regulations for providing against fire risks from electrical apparatus, regulations for the laying of underground cables and the erection of aërial, lines with the precautions to be taken for protection against damage from lightning. They are based on a division into high-tension and low-tension lines, according to whether the voltage is greater or less than 350 volts for alternating, and 250 volts for continuous currents. G. W. DE T.

1627. *Electricity Supply Tariffs.* **A. Wright.** (Inst. Elect. Engin., Journ. 31. pp. 444–486; Discussion, pp. 486–531, March, 1902.)—The costs of supplying electricity may be divided into Preparation and Production costs. Preparation costs consist of—(1) Interest on the preliminary expenses; (2) annual cost of plant and maintenance of it, or the standing-by costs; (3) service costs. The Production cost is defined as the increment of expenditure incurred by making a given plant supply an extra unit of electricity. The author gives methods of separating these two costs from the monthly returns of the station, and shows that the Production costs are small compared with the Preparation costs. Another item of cost is the loss made in supplying a certain class of consumer. The best method of apportioning the standing-by charges to different consumers is by the indications of sluggish maximum demand indicators. An allowance, however, must be made for the fact that all consumers do not make their maximum demand at the same time. A fair allowance for this general diversity in the use of the plant is best made by dividing the annual standing-by costs per kw. demanded, by the ratio of the total of the consumers' individual demands in kw. during the month of maximum load, to the maximum load of that month, and debiting each kw. demanded by the consumer at this new rate. The author recommends that an annual load curve should be drawn for the station, by adding together the number of hours during which any given load has been supplied during the year, and plotting a curve between the percentage of annual maximum load and hours per annum. From this curve can be ascertained: the load-factor at which any proportion of the plant has been used; the ratio of the production and preparation costs at any load; the total cost of production at any load; the number of units sold at any load; the maximum losses economically allowable in the feeders; and what proportion of the plant should be equipped with condensers, economisers and other coal-saving apparatus. Examples of this curve are given for Brighton and Stepney, from which is prepared an analysis of the costs in the Brighton station, and a statement showing the sources of profit and loss. From the latter it appears that against 2,331 consumers who bring in a profit of £4,370, there are 524 who cause a loss of £1,855. Curves are given for Brighton and Nottingham showing the cost of supply to consumers having different load-factors. From these curves the best tariff can be seen. In Brighton this would be 12d. for the first 200 hours per annum and ¾d. afterwards; in Nottingham it would be 8d. for the first 264 hours and ¾d. afterwards. The greater part of the units sold are consumed by the class of small householders, and by shops, with the use of their lamps of 3 to 4 hours per day, and it is their interests which have to be specially consulted in fixing on a tariff. Large consumers should not be encouraged by a system of discounts, as they are often a source of loss. The author then discusses various systems of charging, and points out their defects, and concludes by giving formulæ for calculating the basis of charging on the maximum demand system. *Discussion:* **R. A. Dawbarn** pointed out that the use of maximum demand indicators entails considerable expense in first cost and in maintenance; that a flat rate is fairly applicable to 90 per cent. of

the consumers, and that it is not worth while incurring the expense of giving every consumer an indicator to accommodate a small percentage of consumers. **W. H. Patchell** said that in districts where there is competition the maximum demand system is at a disadvantage, as consumers prefer a flat rate that is fixed, to a system on which they do not know at what rate they will have to pay. **W. M. Mordey** referred to the difficulty in getting consumers to understand the system. He questioned the soundness of the principle ; churches, for instance, are penalised by it, but when a church has a heavy load, the load on the houses of those attending the church is correspondingly diminished, so that the church cannot be said to increase the station load. The cost of the indicators in small installations is an important item, and the loss of pressure in them has also to be considered. He gives a table showing that the average load-factor of stations supplying on a flat rate is higher than that of stations using the maximum demand system. **J. R. Dick** referred to the adoption of Wright's system on the Continent and in America. He mentioned the case of a power company in Silesia, where the supply is made at cost price, and a charge made per kw. demanded. He deprecates the custom of offering supply at a flat rate or on the demand system at the option of the consumer. **L. Andrews** pointed out the difficulties that may arise from the irregularity of quarterly accounts made out under the demand system. He does not advise that it should be forced on consumers, but prefers to change a flat rate, and give long-hour consumers the option of reducing their bills by adopting the demand system. **R. H. Smith** traced out the four stages through which the system has passed. First, there was the Hopkinson scale of an annual charge per lamp, plus a charge per unit ; second, the Wright plan of a charge per watt of annual maximum actual consumption ; third, the plan of basing the charge on the quarterly instead of the annual consumption ; fourth, the application of the diversity factor. Each change has been in the direction of flattening the scale. With the larger introduction of motors the scale will be still further flattened, and perhaps so much as to bring the Wright system down to the old flat rate system. G. H. B.

1628. *Electricity Supply in Bulk.* **H. A. Earle.** (Inst. Elect. Engin., Journ. 31. pp. 884–903 ; Discussion, pp. 903–923, April, 1902.)—The author commenced his paper by referring briefly to the following power schemes : Chèvres [see Abstracts Nos. 2506 (1900) and 579 (1901)], Niagara [see Abstracts Nos. 1193 (1900) and 2031, 2290 (1901)], Massena, Paderno [see Abstracts Nos. 681 (1901) and 995 (1902)], and Vizzola [see Abstract No. 460 (1901)]. In the light of the experience gained at these and other power stations abroad, the schemes of the English power companies cannot, in the author's opinion, be regarded as speculative ventures. The opposition which the promoters of the English schemes had to meet when obtaining parliamentary sanction was based, partly on the objections raised by local authorities, and partly on unfounded fears that the schemes would prove financial failures.

In order to show the fallacies underlying opposition of the latter class, the author has submitted to a detailed examination the prospects of the Yorkshire Electric Power Company's scheme for supplying the West Riding of Yorkshire with electricity in bulk. Within the area covered by the powers granted to this company there is a population of 2,500,000, and 1,000,000 of this total are outside the present area of supply by the eleven towns which have built and are now operating electric supply stations. It is also estimated that within the area covered by the company's Bill there are 27,000 factories and

workshops, utilising 2,000,000 h.p. The present scheme of the Yorkshire Electric Power Company is to erect four generating stations of 25,000 h.p. each. In view of the above figures, there should be little difficulty in finding the requisite number of power users to keep these stations running at their maximum capacity.

The author passes on to an examination of the Yorkshire scheme under the following heads: Board of Trade regulations. General system. Cost of generating stations. Cost of trunk mains. Cost of substations. Cost of distributing and service mains. Total expenditure and capital account. Works cost per unit generated, including management. Trunk mains, upkeep and superintendence. Expenditure at substations and upkeep. Distributing and service mains, upkeep and superintendence. Summary of expenditure per annum. Analysis of total units sold per annum. Total cost per unit sold. Rates of charge. Financial results.

The total capital expenditure upon the four generating stations, mains, transformers, &c., is estimated to amount to £2,666,666.

The running costs and total annual expenditure are calculated for an output of 140,000,000 units, with the following results :—

	Pence per unit.	Total.
Cost of Coal	0·128	£74,666
Oil, Waste, Water, and Stores	0·04	23,400
Wages and Station Staff	0·052	30,000
Repairs and Maintenance	0·05	29,167
Rent, Rates, and Taxes	0·05	29,167
Management, Directors' Fees, Salaries of Chief and Assistant Engineer, Office Salaries, Legal Expenses, Insurance, &c.	0·025	15,000
Sinking Fund on four Generating Stations at £330,000 each—£1,320,000 at 3 per cent.	0·068	39,600
	0·413	£241,000

The Total Annual Expenditure being :—

Annual Expenditure at four Generating Stations, including Office Expenses, &c.	£241,000
Trunk Mains	16,750
Substations	35,250
Distributing and Service Mains	24,750
Annual Expenditure	£317,750

The financial results show a profit of £248,250, as indicated in the statement given below :—

The total units per annum sold equal	123,700,000
Which, at a charge of 1·1d. per unit, yields a gross revenue of	£567,000
The annual expenditure is	317,750
Leaving a profit of	£248,250
And this is equal to :	
4½ per cent. on £666,666 debentures	£ 30,000
and 10·9 per cent. on £2,000,000 share capital	218,250
	£248,250

J. B. C. K.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1629. *Niagara Falls Power Transmission Plant.* (Amer. Inst. Elect. Engin., Trans. 19. pp. 241–253, March, 1902.)—This is a discussion on L. B. Stillwell's paper. [See Abstract No. 412 (1902).] **The Author** stated that improved regulation would be provided for the new alternators, which will ultimately be used for the long-distance service. Owing to the experience that fuses and circuit-breakers without some adjustable relay device might cause a short-circuit on a branch or a substation to interrupt the whole supply, a time-limit device was tried, circuit-breakers on branches from substations being set to open instantaneously, those at the terminal house connecting with substation supply cables, after one second, and those at Niagara controlling the transmission circuit, after three seconds. The arrangement was not, however, entirely reliable. **Lincoln**, after referring to the author's experiences as to the continuous depreciation of rubber cables by heat, stated that he had found a similar depreciation through continued static strain, and attributed this depreciation to the effect of the ozone which was produced under these conditions. **Perrine**, in reply to a question by **Steinmetz**, stated that on long lines he had, or protection against lightning, used a guard line of barbed wire, grounded through an earth plate at every fourth pole, which had the effect of keeping the line continuously discharged. When this was not employed, strong shocks were usually obtained on touching the line when idle. G. W. DE T.

1630. *New Generating Station at Rochester, N.Y.* (Power, N.Y. 22. pp. 1–6, Feb., 1902, and Elect. Rev., N.Y. 40. pp. 146–152, Feb. 1, 1902.)—The old plant has been replaced by a combined steam and water plant. The generating apparatus consists of six 1,360-kw., 2;500 volt, 60 $\sim$, 2-phase, 90 r.p.m. steam sets, and three 350-kw., 2,500, 6 $\sim$, 2-phase, waterwheel sets. The former are of the revolving field type. Two separate steam-driven 75-kw. exciters are provided. The engine-room has mezzanine floors, carrying the various steam-pipes, &c., and is on a lower level than the boiler-house. The Babcock & Willcox boilers are fed by Acme stokers. The boilers are each rated at 650 h.p., and have a heating surface of 6,500 sq. ft. Arrangements have been made for the future use of superheaters. The engines are of the vertical cross-compound type, by the Southwark Foundry and Machine Company, Philadelphia. The normal steam pressure is 160 lbs., and the consumption 13·5 lbs. per i.h.p.-hour. The internal variation of speed is $\frac{1}{4}$ of one geometrical degree from the mean. The governor controls both high and low pressure cylinders, and is of the Porter type. The King synchronising device is employed. Single throw oil switches are used. The instruments include polyphase wattmeters and power factor indicators. The cables are of the paper, lead-covered, duplex type, drawn into tile ducts. The substations are equipped with synchronous-motor-generator sets of 500 kw. and 75 kw. The low-tension cables are of the concentric paper type. The installation of such a high proportion of steam plant where water-power is available is justified by the promoters on the grounds that water-power is fitful and uncertain, and has to be utilised, in this case, at several points ; and that with cheap prices the fuel is but a small proportion of the cost of production. [See also Abstract No. 719 (1901).] E. H. C.-H.

1631. *Overhead and Underground Railway in Berlin.* **Langbein.** (Zeitschr. Vereines Deutsch. Ing. 46. pp. 217–245, Feb. 15, pp. 261–272, Feb. 22, and

pp. 302–315, March 1, 1902.)—This railway, which was completed about the beginning of this year, runs through the southern part of Berlin from east to west, starting at the Zoological Garden and ending at the Warsaw Bridge. A short length is constructed in a double tunnel, about a mile long; the remainder of the line is carried through the streets by means of an overhead viaduct about 5 miles long. The first article is concerned with the description of the construction of the viaducts, tunnels, and permanent way. The rails used are of two kinds, one being 180 mm. high with sleepers 1·5 m. apart, used on iron viaducts, and the other 115 mm. high with sleepers 71 cm. apart, used with the ordinary ballast construction. Direct current is supplied at 750 volts from the power-house; the third rail, carrying the outgoing current, has a cross-section of about 3,600 sq. mm.; it is laid in lengths of 12 m. on vulcanite insulators and jointed with fishplates and copper bonds; it is laid 1,096 mm. from the centre of the track and 180 mm. above the level of the rails, except in the tunnels, where it is 50 mm. higher, in order to facilitate the switching on and off of the lighting circuits. The pressure at the further end of the line amounts to 660 volts; the station lighting is therefore carried out at this pressure, series resistances being inserted at those stations near the power-house; either 12 arc lamps in series or 3 incandescent lamps in series are used. The power-house is nearly in the middle of the line. There are 6 water-tube boilers, each with 230 sq. m. of heating surface; they are provided with superheaters, giving a steam temperature of 225° C. at a pressure of 10 atmospheres. There are two steam feed-pumps, each supplying 40 cubic metres per hour. The engine-room is on the ground floor, the boilers being arranged overhead. The chimney is 80 m. high and 3·5 m. in diameter, but as the boilers are 15 m. above the ground level the available height of the chimney is only 65 m. The engine-room is divided by iron columns into two halves, and is traversed by two electric cranes of 15 and 20 tons capacity respectively. The plant includes three 800-kw. steam sets running at 115 r.p.m. The engines are of the vertical compound type, with cylinders 800 mm. and 1,270 mm. in diameter, and 750 mm. stroke, giving normally 900 h.p. with a steam pressure of 9 atmospheres and an overload of 1,200 h.p. The flywheels weigh about 33,000 kg. The dynamos are shunt-wound and give 800 kw. at 750 volts. The battery is capable of giving 800 kw. for one hour. Each train consists of three coaches, each of which has seats for about forty passengers and standing room for thirty more. The front and back carriages carry three motors each, fitted in the bogies, there being room, however, for four if they should be found necessary. The maximum speed is 50 km. per hour. Brakes operated by hand or by pneumatic pressure are ordinarily used, but in emergency a short-circuiting brake can be applied. On each side of each carriage there is a current collector; so that each train has in all six collectors. The line is said to have cost £150,000 per km., including expenses of all kinds, while the Metropolitan Railway in Paris cost £175,000 and the Central London Railway £375,000 per km. The articles contain a large number of drawings and illustrations of all kinds, 150 in all. W. H. S.

1632. *Wallasey Electric Tramways.* (Tram. Rly. World, 11. pp. 217–221, April, 1902.)—These tramways cover about 8½ miles of road with 10½ miles of single track. The route is mostly comparatively level, but there is a short gradient of 1 in 14. The rails weigh 98 lbs. per yard, they are in 60-ft. lengths, they are 7 in. wide and 7 in. deep. Flat sole-plates ⅝ in. thick are used at the joints. Chicago bonds are used. The trolley wires are

of 000 gauge, and double wires are used throughout. Ten miles of feeders, varying from 0·2 to 0·4 sq. in., have been laid. The generating station contains four Lancashire boilers 28 ft. by 7 ft. 6 in., and one Babcock and Wilcox boiler. A Green's economiser of 256 tubes is employed. The station contains five Ferranti alternators, ranging from 75 kw. to 300 kw. direct coupled to Ferranti and Browett and Lindley engines. The traction plant consists of two 300-kilowatt 6-pole generators 10 per cent. over-compounded, driven directly at 320 r.p.m. by two vertical compound engines, built by Messrs. Galloway, who have also built the separate condensing plant.

A. E. L.

1633. *Burnley Electric Tramways.* (Tram. Rly. World, 11. pp. 199–210, April, 1902.)—These tramways cover about 7½ miles of route laid with a 4-ft. gauge. The gradients are severe, the steepest being 1 in 16 for a distance of about 50 yards. The smallest curve-radius is 70 ft. The rails weigh 102 lbs. per yard; they are in 60-ft. lengths, are 7 in. wide at the base, and 3¾ in. at the head. The groove is 1⅛ in. wide. The specification required the following analysis: Carbon 0·4 per cent., phosphorus not more than 0·08 per cent., silicon 0·15 per cent., sulphur 0·06 per cent., manganese 0·1 per cent. In addition to fish-plates 24 in. long, weighing 38 lbs. per pair, anchor-plates of similar section to the rails are used at each joint. Both Crown and Edison-Brown bonds are used at each joint, and the rails are cross-bonded every 50 yards. The trolley wires are carried by centre bracket poles, side bracket poles, and by span wires in different parts. There are two feeders, supplied by the British Insulated Wire Company, and drawn into Sykes' patent conduits. The generating station contains five Lancashire boilers 7 ft. by 28 ft., with two Proctor and one Leach mechanical stokers. There are two Green's economisers, one of 190 and one of 120 tubes. The coal consumption is about 16 lbs. of slack at 9s. 6d. per ton per kw.-hour delivered. Three horizontal compound condensing engines, two of 150 h.p. each and the other of 200 h.p., drive by ropes two-pole dynamos, giving 440 volts for lighting and 550 volts for traction. There are also two new direct-coupled sets, consisting of 450-h.p. Belliss engines and E.C.C. dynamos. A Tudor battery, capable of giving 40 amperes for one hour, is used in conjunction with Highfield boosters. There are twenty-four cars 33 ft. 10 in. long over all, and weighing, with their maximum traction trucks and two 37-h.p. motors, 12 tons each. The average energy required per car mile is 1·4 kw.-hours.

A. E. L.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

1634. *Deterioration of Steel Rails.* **T. Andrews.** (Engineering, 73. pp. 501–504, April 18, 1902.)—About 12 ft. of Bessemer steel rail, which had stood the main line traffic of an English Railway Company for fifteen years, was submitted to the author, who gives the results of careful external examination, chemical analyses, physical tests, and high-power microscopical observations. The rail had suffered loss in weight amounting to about 1·15 lbs. per yard per annum, partly due to corrosive influences, but mainly attributable to the great excess of sulphur and phosphorus, which impurities in excess induce a more rapid disintegration of steel rails. The corrosive effects were much more marked where the rail had lain in the chairs, due to the

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

fact that galvanic action arises between the cast-metal chair and the steel rail when in a damp condition. Local segregation of the chemical constituents had also occurred to some extent, and had it not been for the comparatively low proportion of carbon and manganese, the author considers the rail would never have stood so long. The high-power microscopical examination showed the general structure of the rail face to be fairly good, but an examination of a section immediately below the surface showed the steel to be honeycombed with innumerable micro-flaws (caused chiefly by the excess of impurities) which undermined the rail, and were capable of developing to any extent, and would undoubtedly have soon led to the fracture of the rail.

The results point to the necessity of careful chemical analyses and physical tests in ordering new rails, and also of carefully watching those in use, and removing them as they show signs of excessive deterioration.

C. E. A.

1635. *Electric Railway Practice and Apparatus.* (Amer. Inst. Elect. Engin., Trans. 19. pp. 273–306, March, 1902.)—This is a discussion of papers by A. H. Armstrong and E. J. Berg [see Abstracts Nos. 418 and 419 (1902)]. After some remarks by **G. Gillon** and **Janisch** on the Berlin-Zossen experiments [see Abstracts Nos. 598 and 797 (1902)], **B. J. Arnold** expressed his belief in the future of the alternate-current motor for railway work, and suggested that the example of a line selected by E. J. Berg was exceptionally favourable to the continuous-current one. If a somewhat longer line had been selected, he suggested that the figures might have been modified, and stated that the alternate-current motor appeared to him the ideal thing for heavy, long-distance railway work at high speeds, and that he looked to the manufacturing engineers of the country to solve this problem. **Mailloux** considered that the alternate-current motor was, under existing conditions, practically precluded from use for high-speed service on short runs, subsequently explaining that by high speed he meant a schedule speed of 45 to 50 miles an hour, involving car speeds of from 60 to 80. The alternate-current motor was not as good as the continuous-current one for high-speed rapid transit service, for the reason that initial angle or mean rate of acceleration could not become as high with the former as with the latter. This was due to the fact that, at present, alternate-current motors can develope a maximum starting torque of from two and a half to three times the normal full load torque only, whereas a continuous-current motor can develope a maximum, which may reach as high as from six to ten times the mean effort. His investigations had so far led him to the conclusion that it is impossible, in relatively short runs, to obtain a mean angle of acceleration sufficiently steep, with the alternate-current motor, to give the schedule time required for high-speed service. If the run is sufficiently long this can be done, but for runs up to a mile and a half, or perhaps more, the difficulties of obtaining a sufficiently high rate of acceleration are too great for the existence of any hope of an immediate solution being found. **G. Gillon** observed that, in the transformer motor-car, the starting torque of three-phase motors could be increased at will by raising the e.m.f. at their terminals by means of a few supplementary winding turns. This was more especially possible in the secondary of the transformers, inasmuch as the starting torque increases in proportion to the square of the applied e.m.f. **E. P. Roberts** called attention to the case of through and local service on the same line, and expressed the hope that it might become possible to eliminate the sub-

stations, with the corresponding interest, repair and depreciation accounts for the investment in rotating machinery, and the salaries for attendants. Capitalising salaries and adding to the cost of machinery makes the total first cost of substations a very considerable percentage of the total cost of an interurban electric railway, and a great increase per mile as compared with 10 to 15 mile continuous-current lines. He did not consider it probable that substations could be dispensed with on the ordinary interurban line, except by so increasing the fuel cost of the generating machinery, line work, and car equipment, as to more than offset the advantage gained. He gave the following table, embracing the results of measurements of 500 miles running over four lines, of cars each provided with four 50-h.p. motors of about the same size and weight, but differing in gearing, maximum and schedule speeds, number of stops per mile and grades of line. No. 1—high schedule and maximum speeds, level line; No. 2—medium schedule speed, level line; No. 3—medium schedule speed, considerable grades and curves; No. 4—medium schedule speed, heavy grades and curves; the schedule speed being exclusive of the lay-over at the end, and the kw. being taken at the car.

	Speed.			Average stops per mile in Country.	Kw. per Mile		Average kw.	
	Schedule.	Maximum.	Running.		In Country	In City.	In Country.	In City.
No. 1	26·2	55	41	0·85	2·88	2·11	73·3	21·1
No. 2	20·5	43	32	1·41	2·85	2·27	56·8	21·6
No. 3	20·4	39	25	0·70	2·18	3·36[1]	48·5	26·5
No. 4	20·6	47	24	0·56	2·18	2·32	47·8	23·4

[1] Unusual load and stops.

The maximum current was 400 amperes in No. 1, starting, and No. 3, accelerating on grade. The maximum grade in No. 3 was 12 per cent. for about half a mile, taking 15·7 kw. per car mile. He referred to the problem, in designing new lines with traffic yet undeveloped, of the greater initial economy of providing fewer substations, with heavier feeders, while with increasing traffic it became more economical to have lighter feeders and more frequent substations. **Stillwell** pointed out that a limitation of the substation plan, which plays an important part in heavy town lines, is to be found in the fact that a reserve of machinery is required at each substation. For example, in the case of the Manhattan Railway, seven 5,000-kw. alternators take care of the maximum load, with one in reserve. Seven sub-station equipments consist of twenty-six 1,500-kw. converters, with seven in reserve, giving a total of 40,000-kw. capacity for the power plant, and 49,500 in the substations. High acceleration is imperative in large towns to secure the maximum speed, and consequently, the maximum passenger-carrying capacity; but it is limited in practice by the fluctuating over-loads on the sub-station apparatus, which, in the case of numerous sub-stations, equalise each other, to a large extent, at the power-house. For example, some calculations for eight-car express trains, running on two minutes' headway, appeared to show that the increase of load on the rotary converters in a sub-

station might amount to as much as 10,000 h.p. in three seconds, coming up to rolling mill practice. This serious difficulty would be eliminated if alternate-current motors could be employed. If this development were effected, it could hardly be expected to increase the 80 per cent. efficiency from engines to motors with substation converters to more than 90 per cent. Now the power bill is about 30 per cent. of the operating expenses, or, on the average, about 18 per cent. of the gross receipts, in the case of American elevated railways. This would only effect a saving equivalent to 2 per cent. on the income, not sufficient to justify an experiment on a large scale, and this sufficiently accounted for no stronger efforts having been made in America to solve this problem. He considered, moreover, that if this gain could be effected, it would be more than counterbalanced by the risk attending the use of high voltage in large towns, except perhaps in tunnels. **E. P. Roberts** mentioned a case in which three cars running at high speed gave fluctuations of as much as 1,000 amperes at the continuous-current switchboard, and suggested that, in such cases, the question of using secondary batteries deserved serious consideration. **Steinmetz** stated that, in every case he had investigated, he had come to the conclusion that the transmission efficiency of the three-phase system would be lower than that of the continuous current, owing to the comparatively low efficiency of the induction motor under service conditions. The load fluctuations would be increased by eliminating the converter by the introduction of three-phase motors, for the torque increases with the current at a much higher rate with a continuous-current series motor than with an induction motor, and, moreover, the static transformers used with the latter will not stand overloading to anything like the extent possible with the converter. As regards reserve machinery, the elimination of the converter may in many cases greatly increase the necessary reserve capacity, and this will be continuously in circuit in the form of static transformers, for a small line loss is essential to avoid a heavy drop of voltage with the excessive starting current ; otherwise an excessive overload motor capacity would have to be provided, with consequent very low efficiency and small power factor under normal conditions. **Scott** stated that he had obtained figures very closely agreeing with those of Berg. The braking advantage of induction motors, he considered, was more than counterbalanced by the increased motor weight necessary if they were to be so used. In order to obtain the maximum advantage in braking it is necessary to begin braking at the highest speed. The energy which might thus be returned to the line could be much better employed in slightly changing the conditions, and using it for overcoming friction by drifting. Electric braking cannot be effected below half speed, and in many cases it will be possible to drift down to this, or lower. The constant speed of the induction motor on varying grades was claimed as an advantage. His point of view was that this was a serious limitation to the speed, the continuous-current motor, by its capability of variation, giving a much higher average speed. **Steinmetz,** in reply to a remark by **Stillwell,** stated that the advantage claimed for the induction motor of returning energy in concatenation during retardation, is one not borne out by numerical investigation. Running at synchronism until braking begins, the most wasteful method of working, such a return of energy is obtained. As Mailloux had pointed out, however, the proper method of working under rapid transit conditions, that is, the way to carry the motor in a given time over a given distance, with the minimum expenditure of energy, is to accelerate, as fast as possible, to high speed, then shut off the power and

drift until the time for braking arrives, as this devotes to necessary operation a large part of the energy otherwise dissipated in braking. Now, with the three-phase motor, where the maximum speed is slightly below synchronism, and drifting is begun at this speed, at the end of the drift the speed will have fallen to nearly the half, and it is only above half-speed that energy can be returned. The induction motor as an electric brake for returning energy is, therefore, unsuitable for rapid transit work. Concatenation to start and attain half-speed is correct, but even then the efficiency is inferior to that of a series controlled continuous-current motor. Two concatenated motors are lower in efficiency than two continuous-current motors in series, the current of the first motor being in excess. G. W. DE T.

1636. *Westinghouse Magnetic Brake for Tramcars.* (Mech. Eng. 9. pp. 626–628, May 10, 1902.)—The brake consists of a horse-shoe magnet, suspended by spiral springs from the car frame, the two poles hanging down directly over the rail. The short-circuited motor current is passed round the exciting coil of the magnet, the result being that the poles are drawn downwards by the steel rail. The poles are fitted with soft iron shoes, which grip the rail, the whole forming a kind of slipper brake. The poles are also connected by levers which apply a brake to the wheel rims. Various forms of braking action are therefore applied at the same time by moving the handle of the controller beyond the "off" position in the opposite direction to that which starts the car. W. H. S.

1637. *Electric Heating of Trains.* **J. A. Montpellier.** (Électricien, 23. pp. 225–226, April 12, 1902.)—On the electric railway to Versailles a system of electric heating has been adopted in the carriages which has given satisfaction. In each of the carriages, which are of the central corridor class, ten heaters are placed on the floor between the seats, so that they act as foot-warmers. The heaters are of the Parvillée construction, in which the resistance consists of a mixture of a metallic powder, quartz, kaolin, and a flux [see Abstract No. 903 (1899)], and are connected five in series—being supplied from the third rail at 550–600 volts. At 110 volts each takes 1 ampere, and the total power for each carriage, which seats forty passengers, is therefore 1,100 watts. Assuming a cost of 15 centimes per kw.-hour, it follows that the expense of sixteen hours' use will be 2·64 francs. The mean temperature measured at the surface of the heaters is 70° when the external temperature is 0°. It is claimed that the method is more convenient and less expensive than other systems. W. W. H. G.

1638. *Railway Signalling.* (Engineering, 73. p. 184, Feb. 7, 1902.)—An invention of J. Netter and H. Queyroul consists of a thin copper wire held between two arms over the engine cab. The wire is broken on coming into contact with a rod extended from the line signal. This opens an electric circuit, and works a signal disc and alarm-bell inside the cab, thus apprising the driver of "danger." For running through tunnels and under low-arched bridges the arrangement is automatically lowered and then raised again, as follows: Two metallic brushes are fixed under the engine, and old rails are placed between the track rails, one in front and one behind the tunnel or arch, in such a position that one brush is earthed on one side, and the other on the other side, of the place where the bow has to be lowered and again raised. By means of a small 20-volt and 12-ampere-hour accumulator on the engine, an electromagnet is caused, when one brush is to earth, to pull down the bow by moving an iron core, and when the other

brush is earthed, a second electromagnet operates in the same fashion to restore the bow to normal position. While it is down, an alarm-bell is kept ringing. Drawings of the apparatus are given. It has been tested on express trains running at maximum speed, and has worked satisfactorily. The broken wire is easily replaced while the train is running. E. O. W.

1639. *Russian Electric Block-Signalling.* (West. Electn. 30. p. 386, May 31, 1902. From Elektrotechnik, St. Petersburgh.)—At the Moscow Convention of electrical engineers the following block system was considered the best device submitted to meet the conditions of the problem set for examination. The contacts of the rails are to be utilised. They shall work only when a train passes, and must not be actuated when only a hand-car passes, or the road-bed is shaken by work going on near by. The contact must be long enough and good enough for the current to operate the necessary apparatus. The contacts must not be affected by atmospheric conditions. Constructions, repairs, and maintenance of the contacts must be easy. The device described depends upon the deviation of the rail, or its ductility under a train. It begins to bend under the first wheel, and there is thus time during the passage of the whole train for the bending to take effect at the electrical contact. A beam of iron is fastened on two adjacent sleepers. In the middle of the space between the sleepers a box is fastened vertically to the beam. This box contains an arrangement of levers required for the transmission of the motion and for the formation of a contact. There is an opening for a cable, and another for a pin which is set vertically, and rests at its lower end upon a brace connected to the base of the rail. The pin descends when the rail is bent, and an electrical contact takes place inside the box, bringing the cable into circuit. Thus a signal can of course be operated. The pin and cable holes in the box are presumably watertight. In case the pin should rise above its normal position, by temperature changes, &c., it pushes the contact "off" and not "on," and no fault is therefore likely to happen. E. O. W.

1640. *Block-signals for Single-line Railways.* **L. Kohlfürst.** (Elektrotechn. Zeitschr. 23. pp. 240–242, March 20, 1902.)—In this system, which is in use on the Buffalo-Lake Erie Railway, there is arranged, at each end of the single-line section, a box having three superposed compartments. The uppermost of these compartments contains two incandescent lamps showing a white light, the middle one contains two incandescent lamps showing a red light, whilst the lowermost, one contains a two-point switch, to which access can only be had by the guards of the trains using the line. These switches are so constructed that they cannot remain in an intermediate position, and are connected up with a live wire extending along the single-line track, with the said lamps and with the earth, in such a manner that when the guard, on his train entering the section, turns the switch from one point to the other, a white light will appear at one end and a red at the other; when, however, the train reaches the other end of the section, the guard turns the switch at that end, whereby the lamps at both ends are extinguished, and the line is again clear. Various modifications are described, and several diagrams of connections are given in the original paper. C. K. F.

1641. *Automatic Electric Block-signals.* **L. Kohlfürst.** (Zeitschr. Elektrotechn., Wien. 20. pp. 81–85, Feb. 16; and pp. 112–115, March 2, 1902.) —In this paper, the whole question of electric block-signals is discussed, both

with respect to European and American practice. The following points are considered, viz.: The conditions to be fulfilled by block-signals; the relative advantages of the various kinds of signals (disc, semaphore, &c.); the numbers of the different kinds of signals installed each year in the United States; the results of tests made on the Chicago and N.W.R.R.; a list of the obligatory and optional conditions prescribed for block-signals by the American Railways; the results of working the Hall system of electric block-signals on the Chicago and N.W.R.R. The costs of working the last-mentioned signals are as follows: Each electrician at $75 per month supervises about 40 signals on a 32-kilometre section of line. Each battery-attendant at $45 per month looks after the batteries at 20 signals, and assists the electrician. Each lamplighter at $30 per month, attends to the lamps at about 20 signals, and assists the battery-attendant when required. The electrician inspects his section twice a day, and overhauls each signal once a month. The mean costs of maintaining and working each signal in 1898 was $83·61, apportioned as follows: Labour and material for the signal, $32·33.; for the battery, $30·42; and for the lighting, $20·86. The resistances of the lines and instruments and the currents taken thereby are also given. E. C. Carter, the general manager of the railroad, describes the system as trustworthy when properly installed and carefully maintained. [See also Abstract No. 1219 (1901).] C. K. F.

1642. *Electric Train Signalling System.* **R. Bartelmus.** (Zeitschr. Elektrotechn., Wien. 20. pp. 129–132; Discussion, p. 132, March 9, 1902.)—In this system, a single contact-rail is arranged in the middle between the two running rails throughout the line. This contact-rail is interrupted every 200 m., these interruptions being each bridged by a resistance of 1 ohm. On the locomotive is mounted a direct-driven shunt-wound dynamo giving 60 volts. One terminal of the dynamo is connected to the frame of the locomotive, and the other to a contact-loop which slides over the central third rail, the circuit including various electromagnetic indicators and switches. As this locomotive approaches a short-circuit or connection between the running and third rails, the current in the dynamo circuit gradually increases, and successively shows a green light, an audible alarm, and a red light on the locomotive, and finally automatically closes the steam-valve. Signals can also be given on a locomotive without a dynamo. Signals can be given to the locomotive from the separate carriages by short-circuiting the running and contact rails. Modifications are also described in which the indicating devices are arranged at stations and in signal-boxes, and are connected across the interruptions in the third rail. C. K. F.

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1643. *The New York Rapid Transit Subway.* **C. Prelini.** (Engineering, 72. pp. 477–480, 507–510, 547, 576–577, 637, 674–676, 699–700, 737–740, 763–765, 857–858, Oct. 4 to Dec. 27, 1901; and 73. pp. 11, 40–44, 112, 141–143, 205–208, 245–246, 276–277, 364–365, 429–430, 464–466, Jan. 3 to April 11, 1902.)—These papers contain a very comprehensive and detailed description, with numerous illustrations, of the construction of this important undertaking. [See also Abstract No. 793 (1902).] G. W. de T.

1644. *The Telephone in Railroad Work.* **M. Garl.** (American Telephone Journal, 5. pp. 34–36, Jan. 18, 1902.)

TELEGRAPHY AND TELEPHONY.

1645. *Effects of Contacts upon Telegraphic and Telephonic Currents.* **J. de Pauw.** (Soc. Belge Élect., Bull. 19. pp. 9–11; Discussion, pp. 11–14, Jan., 1902.)—When two wires covered with oxide are in contact, telephonic conversation is not interfered with; and when the oxide is thick enough the alternate currents from a magneto are also obstructed by it. The author views the oxide of copper as a dielectric, for both undulatory and alternating currents. He quotes a case on the line from Brussels to Paris where, during a contact, telephonic communication was good, but telegraphic indifferent. A similar effect was noticed during a thick frost when the wires were in contact between Leuze and Tournai. The frozen particles acted as a dielectric in the one case and as a conductor in the other. Several speakers quoted cases where telephonic circuits, even 7 km. in length, laid on ice or dry snow, have been successfully operated—at Ixelles, Mt. Blanc, and St. Bernard, for instance. Here the insulating property of snow and ice comes into play.

E. O. W.

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1646. *New Equipment of Chicago Fire-alarm System.* (West. Electn. 30. pp. 91–92, Feb. 8, 1902.)

1647. *Glasgow Corporation Telephone Exchange.* (Elect. Engin. 28. pp. 330–334, Sept. 6, 1901.)

1648. *New Transmitter of the German Post Office.* **J. Baumann.** (Électricien, 22. pp. 161–164, Sept. 14, 1901.)

1649. *Changing a Magneto Drop to a Central Battery System.* **C. L. Goodrum.** (Elect. World and Engineer, 38. pp. 547–548, Oct. 5, 1901.)

1650. *Recent Common Battery Telephone Exchange Work in New York City.* **H. L. Webb.** (Elect. World and Engineer, 38. pp. 925–928, Dec. 7, 1901.)

1651. *Telephone Exchange System of the Maryland Telephone and Telegraph Company.* **K. B. Miller.** (Elect. World and Engineer, 38. pp. 921–925, Dec. 7, 1901.)

1652. *Hotel Telephone Exchanges in Chicago.* (West. Electn. 29. pp. 381–382, Dec. 14, 1901.)

1653. *The Bell Telephone Company's Central Energy System.* **W. S. Henry.** (Amer. Electn. 14. pp. 36–38, Jan., 1902.)

1654. *Independent Telephony at Charleston, W. Va.* (Elect. Rev. N.Y. 40. pp. 274–275, Feb. 22, 1902.)

SCIENCE ABSTRACTS.

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GENERAL PHYSICS.

1655. *Mercury Air-pumps.* **G. W. A. Kahlbaum.** (Ann. d. Physik, 8. 2. pp. 466–471, May, 1902.)—This paper contains a reply to F. Neesen's criticism [see Abstract No. 1271 (1902)] on G. W. A. Kahlbaum's paper on air-pumps [see Abstract No. 1 (1902)]. The use of the different luminous effects successively obtained in the exhaustion of a Crookes' tube, as standards of pressure, is considered to be unsatisfactory, for the reasons that the eye is not able to detect with sufficient rapidity the first appearance of each effect, and also that the effects are liable to vary with the current. Replies are also given to the other points raised. C. K. F.

1656. *Cavendish Balance.* **G. K. Burgess.** (Phys. Rev. 14. pp. 247–256, April, 1902.)—A modification is described in which the weight of the turning system is compensated by a float immersed in a mercury bath, and any capillary action is eliminated that might tend to hinder the mobility of the system. Any degree of sensitiveness can be obtained. Preliminary experiments gave the constant of gravitation $6{\cdot}64\ 10^{-8}$ and the earth's density 5·55. [Summary of a Sorbonne thesis, 1901 : work done under Prof. Lippmann.] A. D.

1657. *Divergence of Long Plumb-lines in a Deep Mine.* **F. W. McNair.** (Eng. and Mining Journ. 73. pp. 578–580, April 26, 1902.)—The plumb-lines were used to transfer an azimuth from the surface to an underground level, and were 4,250 ft. in length, greater than in any case previously recorded. They consisted of No. 24 piano wire, and the bobs were of cast iron, weighing 50 pounds each, the latter being swung in pails of cylinder oil for damping the vibrations. Measurements between their upper and lower extremities showed a divergence of 11 ft. Magnetic and other disturbances were suggested and sought for, but, after a very thorough investigation, the displacement was found to be simply due to air-currents. G. G.

1658. *New Hygrometric Method.* **E. B. H. Wade.** (Phil. Mag. 3. pp. 380–385, April, 1902. Paper read before the Physical Society, Dec. 13, 1901.)—The note describes a new hygrometric method in which the ther-

mometer is wetted, not with water, but with sulphuric acid of suitable strength, and it is claimed that the method is (1) theoretically sound, (2) cheap and easy to manipulate, (3) specially suited for the study of ordinary wet-bulbs, (4) independent of ventilation. A description of the theory and method of manipulation is given, and tables of results are cited. J. W. P.

1659. *Films of Minute Metallic Particles.* **R. W. Wood.** (Phil. Mag. 3. pp. 396–410, April, 1902. Paper read before the Physical Society, March 14, 1902.)—The author has made "metallic deposits on glass, which the microscope shows to be made up of particles smaller than the wave-lengths of light, and which by transmitted light, exhibit colours quite as brilliant as those produced by aniline dyes." The deposits are obtained by heating small fragments of the alkali metals in glass bulbs thoroughly exhausted and sealed, the method of preparation being described in detail. Sodium films were prepared, coloured deep purple, blue, apple-green, or red, according to conditions. Some of the more transparent films, examined under a $\frac{1}{12}$ in. oil objective, proved to be composed of particles just barely visible as individual grains lying close together. When air is admitted into the tube the colour vanishes instantly, but pure hydrogen has no effect. The diameter of the particles varies from 0·0003 to 0·0002 mm. Coarse particles diffract or scatter the light, minute particles very close together regularly reflect those wave-lengths absent in the transmitted light, and minute particles far apart diffuse light of the same wave-lengths as those which are, to some extent, absent in the transmitted light. Heating and cooling both affect the colour in such a way that the absorption region of its spectrum shifts in the direction of greater wave-lengths, but the effect due to cooling is temporary. Thus a pale green film becomes deep violet when cooled. Some films are so sensitive that the change and return of colour can be produced by merely blowing, and then rubbing with the finger. The films are practically electrically non-conducting, and the maximum polarisation of light is obtained at about 135° to the incident ray. The author suspects the phenomena to be due to a kind of electrical resonance. G. E. A.

1660. *Dynamical Aspect of Stability of Structures.* **A. Sommerfeld.** (Zeitschr. Vereines Deutsch. Ing. 46. pp. 391–394, March 15, 1902. Paper read before the Aachener Bezirksverein, July 3, 1901.)—In a structure such as a pillar subject to varying load, considerations of resonance come in, and the real or dynamical displacement is not the statical displacement for the maximum load, but is equal to the latter multiplied by a "dynamical coefficient" γ. A similar statement holds for a flywheel subject to a periodic couple. For a pillar built in at the bottom, for instance, γ depends on the load, the weight of the pillar, the Young's modulus of its material, the moment of inertia of its section, its length, and particularly on the frequency of variation of the load. For very small frequency γ is approximately unity, while a critical frequency is reached for which the dynamical displacement is much greater than the statical, decreasing for higher frequencies. The critical frequency is that for which the period of the load is the natural period of the pillar, and must in practice be avoided; this may be effected in various ways, the safest in practice being to increase the section of the pillar till the natural frequency of the pillar is, say, ten times that of the load. The author considers also the case of a flywheel governed by the torsional couple in a spring, and shows that in this case the usual statical methods may lead to serious error. The results were illustrated by experiments. W. S.

1661. *Specification of Stress and Strain in an Elastic Solid.* **Kelvin.** (Phil. Mag. 3. pp. 444–448, April, 1902.)—This is a continuation of Kelvin's former paper [see Abstract No. 1023 (1902)]. He introduces for perspicuity an auxiliary tetrahedron, similar to the tetrahedron A B C D of the former article, defined by the relation that $\alpha\beta\gamma\delta$, the angles of the new tetrahedron, are the centres of gravity of the four triangular faces of A B C D. By this and the former paper he has completed, he says, the foundation of the molar dynamics of an elastic solid of the most general possible kind according to Green's theory, without restriction to infinitely small strains. The rest of the present paper is occupied with the geometry of tetrahedrons and of the strain ellipsoid. Let, for instance, a sphere be inscribed touching each of the six edges of an equilateral tetrahedron in their middle points, and having, therefore, its centre at K, the centre of the tetrahedron. When the solid is altered by homogeneous strain, the inscribed sphere becomes the strain ellipsoid, which still has its centre at K, and touches the six edges of the altered tetrahedron at their middle points. S. H. B.

1662. *Stability of Equilibrium of a Pear-shaped Rotating Fluid.* **H. Poincaré.** (Roy. Soc., Phil. Trans. 198. pp. 333–373, April 5, 1902.)—The present paper is a continuation of the author's memoir on the same subject ("Acta Mathematica," vol. 7). It should be read in connection with that former memoir, and with the recent papers by G. H. Darwin, on "Ellipsoidal Harmonics," and on the pear-shaped figures.

We are to suppose a series of Jacobian ellipsoids of stable equilibrium becoming more elongated until we arrive at the "critical Jacobian," or "ellipsoid of bifurcation," which is also the limit of the series of pear-shaped bodies. It is defined, according to Darwin, by the vanishing of one of the coefficients of stability. Darwin has also determined its axes, namely, 1·88583, 0·81498, 0·65066. In the present paper ω denotes the angular velocity, and J the moment of inertia, of the body under consideration. For the critical Jacobian these are denoted by ω_0 and J_0. Further, the equation of the critical Jacobian is

$$\frac{x^2}{\rho_0^2-a^2}+\frac{y^2}{\rho_0^2-b^2}+\frac{z^2}{\rho_0^2-c^2}=1,$$

And the elliptical co-ordinates, ρ, μ, ν, used in this paper are derived from it. The criteria of stability may be presented in either of two forms. We may make, that is, $U+\frac{1}{2}\omega^2 J$ a minimum, given ω, where U denotes the potential; or we may make $U-\frac{1}{2}\omega^2 J$ a minimum, given ωJ. The first condition is applicable, our author says, to Plateau's experiments, in which the fluid is carried round frictionally by a rotating axis. The second is necessary and sufficient for a homogeneous mass of fluid isolated in space. As we arrive at the critical Jacobian from either series, viz., from the series of Jacobian ellipsoids, or that of the pear-shaped bodies, ω, and likewise ωJ, must be either a maximum or a minimum, and the question is which. M. Poincaré adopts, as the more probable, the hypothesis that ωJ is a minimum at the critical Jacobian, and makes use of the second of the two criteria of stability. The notation employed in this paper is not precisely identical, either with the author's own in the "Acta Mathematica," or with Darwin's. He makes use of the functions R, S, M, N, defined by Lamé and in previous investigations, R having five forms denoted by five indices, R_1, R_2, R_3, R_4, R_5, which are calculable when the axes of the critical Jacobian are known. Of these, R_5 is "the third zonal harmonic," and is the most important for the present investigation. The pear is defined as follows: From the surface of the critical Jacobian draw

normals to the confocal ellipsoids, that is, the lines $\mu =$ constant, $\nu =$ constant. If $d\sigma_0$ be an element of surface of the critical Jacobian, dv the volume formed by $d\sigma_0$, and these lines drawn from points on its boundary, the ratio $dv/d\sigma_0$ is the distance between $d\sigma_0$ and a new surface, and is a function of μ, ν, which he developes in a series of Lamé's functions ξ_1, ξ_2, &c., in the form $dv/d\sigma_0 = \Sigma C\xi_i M_i N_i$. The surface so formed is the pear, and is defined by the ξ coefficients.

We may consider the attracting matter in the space between the pear and the critical Jacobian (the distribution C) as all collected on the surface of the critical Jacobian. Hence is calculated the difference between the attraction of the distribution C and that of the supposed distribution on the critical Jacobian (Σ). The conditions of stability for the pear are finally given in the new form—

$$\frac{\omega J - \omega_0 J_0}{\omega_0 \xi_5^2} = T - XY/T < 0 \text{ (p. 362)},$$

in which T and Y are quantities which he has proved to be negative. He has also found (p. 362)—

$$\xi_5^2 X + \epsilon T = 0,$$

where ϵ is defined as follows: ω_0 being the angular velocity of the critical Jacobian, that of the pear is $\sqrt{\omega_0^2 + 2\epsilon}$. For stability it is sufficient and necessary that ωJ should be a minimum, that is, $\omega J - \omega_0 J_0 > 0$. But, as proved by the author, $\epsilon < 0$. Therefore, since $\xi_5^2 X + \epsilon T = 0$, X must be negative, and this he gives as the final condition for stability. S. H. B.

1663. *A Law of Molecular Attraction.* **J. W. Mellor.** (Phil. Mag. 3. pp. 423–424, April, 1902.)—Van der Waals' well-known formula makes the final of the intermolecular forces in a liquid or vapour vary as the square of the density, on the assumption that the density is at every instant constant throughout the substance except at points very near the boundary, and that the intermolecular forces exactly balance each other always and at all points, except very near the boundary. The author, in the paper, deduces from Van der Waals' formula Sutherland's law, namely, that molecules act on each other with a force varying as the inverse fourth power of the distance. S. H. B.

1664. *Deformation of a Right Isotropic Diedron with Special Boundary Conditions.* **R. Marcolongo.** (Accad. Lincei, Atti, 11. pp. 318–324, April 20, 1902.)—This note refers to Somigliana's paper [see Abstract No. 1285 (1902)], in which is treated the problem of the deformation of a right isotropic diedron with two planes of symmetry, when the displacements and the forces at the bounding surfaces are each given in part. The writer here proposes to show that the general method of Betti-Cerruti can easily be applied to Somigliana's problem. The solid in question is bounded by the half planes $x = 0$ and $z = 0$ (back); on the boundary $x = 0$, $\partial G/\partial x = \partial(1/r)/\partial x$, and on the boundary $z = 0$, $G = 1/r$. Corresponding to any point M_1 in the solid there are three successive images in the planes $z = 0$, $x = 0$, and $z = 0$. The distances from any other point M of M_1 and the three images respectively are r, r_1, r_2, and r_3. Thus, if $G = 1/r_2 + 1/r_3 - 1/r_1$, G satisfies the condition. Also G satisfies the harmonic condition, $\nabla^2 G = 0$, at all points within the solid. This solves the problem for the case in which, on the plane $x = 0$ the values of the normal $\frac{\partial u}{\partial x}$, and on the plane $z = 0$ the values of u itself are given. From this can be found the deformation of the same solid when subjected to any

forces, when on one bounding plane the tangential components of displacement, and on the other the normal components of force are given. If ξ, η, ζ, be the component displacements, the first step to the solution is to find displacements corresponding to zero force with bounding conditions—

$$\text{on } x=0,\ \partial\xi/\partial x = -\partial^2(1/r)/\partial x^2,\ \eta = -\partial(1/r)/\partial y,\ \zeta = -\partial(1/r)/\partial z\ ;$$
$$\text{on } z=0,\ \xi = -\partial(1/r)/\partial x,\ \eta = -\partial(1/r)/\partial y,\ \zeta = -(\partial^2(1/r)/\partial z^2.$$

This displacement ξ, η, ζ, is called the auxiliary displacement. The problem is next to determine the forces to be applied at the boundary in order to produce the auxiliary displacement. From this auxiliary displacement is also found the cubic dilatation (H), at any point, corresponding to the effective deformation, and from this u, v, w are found. Finally, the writer treats the converse problem, in which the normal displacements and the tangential forces are given on the bounding surfaces. S. H. B.

1665. *Particular Solutions of a Hamiltonian System.* **P. Burgatti.** (Accad. Lincei, Atti, 11. pp. 309–314, April 20, 1902.)—If in a system of n degrees of freedom, in which Hamilton's canonical equations are $dq_i/dt = d\mathrm{H}/dp_i, dp_i/dt = d\mathrm{H}/dq_i$, k integrals, or invariable relations, are known, which determine $p_1\ p_2 \ldots p_k$, then Levi Civita's theorem asserts that "if H_1 be what H becomes when for $p_1 \ldots p_k$ we substitute the values deduced from the k integrals, the relations $d\mathrm{H}_1/dp_i = 0$, $d\mathrm{H}_1/dq_i = 0$, $(i = k+1 \ldots n)$, together with those supposed known, constitute a system invariable with respect to the canonical equations." From these equations and the known integrals, the p's and $q_{k+1} \ldots q_n$, can be found as functions of $q_1 \ldots q_k$, and thence, by substitution in the canonical system, we have a system of equations reduced in number by k, from which $q_1 \ldots q_k$ can be found as functions of the time. The motions so obtained are stationary motions in the sense used by Routh and Levi Civita. The object of the present paper is to connect the above theory with the general theory of differential equations. S. H. B.

1666. *Minimum Temperatures at St. Louis, Mo.* **W. H. Hammon** and **F. W. Duenckel.** (Monthly Weather Rev. 30. pp. 12–13, Jan., 1902. Paper read before the St. Louis Academy of Science, March 2, 1896. (Abstract).)—There are two meteorological stations at St. Louis where bituminous coal is burned, the U.S. Weather Bureau, which is on all sides surrounded by chimneys, and the Observatory in the large Forest Park, which is generally free from smoke. The temperature minima at the former station are almost always higher than those at the latter, especially with clear skies and light winds, by 9° F. in September, and by 1·5° F. in December on average, owing probably to the accumulation of smoke. H. B.

1667. *Temperature Variations at High Altitudes.* **L. Teisserenc de Bort.** (Comptes Rendus, 134. pp. 987–989, April 28, 1902.)—The paper gives the results of recent temperature measurements made at high altitudes by means of balloons sent up from the French Observatory for Dynamic Meteorology. The decrease of temperature with increase of altitude augments after the lower strata have been left, and reaches, in regions heretofore explored, a value pretty near that which corresponds to the adiabatic variations of dry air, but this decrease, instead of continuing, as had been anticipated, in the same ratio, was found to reach a maximum, and then rapidly diminish until it became practically nil at an altitude of about 11 km. Above an altitude, varying, according to the atmospheric conditions, between 8 km. and 12 km.,

a zone, extending apparently for several km., is reached, in which there is very little decrease, or even a slight increase, of temperature, spells of heat and cold alternating. This is of serious import for the general study of air circulation. A study of the observations show that the kink in the regular curve of decreasing temperatures occurs at elevations between 8 km. and 13 km. It appears that the diminution of the decrease in temperature corresponding to an increase in altitude which takes place at elevations between 8 km. and 9 km. coincides with periods of atmospheric disturbances and barometrical low pressure, while, under conditions of high pressure, the point at which the regular decrease in temperature stops, and the temperature shows a tendency to become fixed, is raised. The results above stated confirm the author's previously reported discoveries [see Abstract No. 644 (1902)], and supply additional data of great interest. He has recently endeavoured to establish a connection between the variations in the altitude at which the divergence of the curve begins and the general atmospheric conditions, and gives data showing that the isothermal zone near to 12·5 km. in the central portion, north of the area of strong pressures, sinks to 10 km. in the centre of the areas of feeble pressures. G. G.

1668. *The Climatic Conditions of Turin during the year* 1901. **V. Balbi.** (Accad. Sci. Torino, Atti, 37. 10a. pp. 221–249, 1901–1902.)—The paper gives, chiefly in the form of classified tables, data for the temperature, moisture, winds, sunshine, pressure, &c., prevailing in Turin during 1901. The year was characterised by its exceptional humidity; it interrupted, too, the series of years with a temperature notably above the average. D. H. J.

1669. *The Physical Basis of Long-range Weather Forecasts.* **C. Abbe.** (Monthly Weather Rev. 29. pp. 551–561, Dec., 1901.)—This paper is a summary of lectures delivered at the Johns Hopkins University during February, 1901. It contains a lucid digest of the physical conditions to be taken into consideration, and of the progress that has been made in dealing with them. The author's conclusion is that it is only by the study of these general phenomena and their elucidation that we can expect to realise satisfactory long-range weather forecasts, and that this result will be better and earlier attained by the study of the mechanics of the atmosphere than by the search for elusive empirical periodicities. G. W. DE T.

1670. *Cause and Mechanism of Heat-waves.* **H. M. Watts.** (Frank. Inst., Journ. 153. pp. 285–293, April, 1902.)—The causes of heat-waves, in whatever part of the globe, are due to exactly the same general conditions. Local differences exercise no important effect. The meteorological mechanism is simple. The origin is invariably due to a certain stress in the shape of a barometrical high-pressure area in the general circulation, which sets up a movement of air from the tropics toward the polar region. This stress, which is far reaching, its reaction extending all around the globe, slows up, as far as the northern hemisphere is concerned, the normal eastward drift of the serial eddies in the north temperate zone, producing a stagnation in the lower atmospheric levels. The local circulation thus set up modifies the moisture content in the upper levels of the lowermost stratum of the atmosphere, by which radiation at night is checked, and the air thus retains an abnormal amount of the heat gained during the day. Thus vast areas of land favourably situated become overheated, being covered, so to say, by a blanket of superheated air, extending upward to the higher cloud level. The duration

and extent of the heat-waves so caused remain unaffected by local conditions, and a change can be brought about only by a reversal of the south-to-north system of circulation. Heat-waves, therefore, form a part of the so-called fixed and permanent characteristics of the general circulation of the globe, which is characterised by a belt of high pressures near the tropics and a belt of low pressures near, or at, the poles, between which two permanent belts move, in a great eastward swirl, the enormous aërial eddies that condition weather and climate in the temperate zone. Of these aërial eddies, there are only two, *i.e.*, the high-pressure, anticyclonic, downdraught eddy, and the low-pressure, cyclonic, updraught eddy, the former being the centre of clear weather phenomena, the latter that of stormy and cloudy weather. The cause of the reversal in the direction of the circulation from the tropical regions poleward, and the definite shift in the atmospheric stresses, which alone can terminate the duration of the heat-wave, must be found in the sun, and are certainly regulated by law. The author hopes that by the careful study of the cosmological conditions, this law may soon be discovered, and that meteorologists will thus be enabled to forecast seasonal conditions, and to predict with accuracy whether the summer will be hot or cool. A great step will have been reached in the effort of finding the true rhythm in what appear to be capricious changes in the weather of the temperate zones, as soon as it has become possible to forecast the character of the tropical and sub-tropical regions. G. G.

1671. *Nova Persei Nebula.* **W. E. Wilson.** (Roy. Dublin Soc., Proc. 9. pp. 556–558, April 14, 1902.)—The author outlines the view, first stated by Kapteyn, that the variations which have been noted in the surrounding nebulosity of Nova Persei are due to the successive lighting up of the outer extensions of a previously existent nebula by the advancing wave front of the light from the main disturbance.

Adopting this view, the distance of the Nova from the earth can be calculated when we know the velocity of light and the angular displacement of the nebulosity in a given period of time. His result gives the distance of the new star as about 248 *light years, i.e.*, 15,780,000 times the distance of the sun from the earth. Arguments are presented for supporting the view that the nebulous matter has a sufficiently high albedo to reflect enough light at this distance. The method, if true, becomes of extreme importance, in that the distance of a celestial body whose parallax is unknown may be thus determined.

C. P. B.

REFERENCES.

1672. *Level Tester, by Bamberg.* **C. Aimonetti.** (Accad. Sci. Torino, Atti, 37. 5a. pp. 119–136, 1901–1902.)—A description of the testing of the instrument is given. A. D.

1673. *Coefficient of Diffusion from Optical Data.* **J. Thovert.** (Comptes Rendus, 134. pp. 594–596, March 10, 1902.)—Numerical data obtained by the method referred to in Abstract No. 432 (1902) with certain described modifications. A. D.

1674. *Effect of Pressure on Curved Surfaces.* **C. Bach.** (Zeitschr. Vereines Deutsch. Ing. 46. pp. 333–341, March 8, and pp. 375–380, March 15, 1902.)—An experimental investigation to determine formulæ expressing the power of resisting pressure when applied to the convex surfaces of copper and iron vessels.

W. W. H. G.

LIGHT.

1675. *Absorption of Light Rays by Thin Layers of Metal.* **E. Hagen** and **H. Rubens.** (Deutsch. Phys. Gesell., Verh. 4. 5. pp. 55–63, March 7, 1902. Communicated by the Physikalisch-Technischen Reichsanstalt.)—The infra-red, visible and ultra-violet rays from an arc lamp are examined, before and after interposition of the metals, by means of a special spectroscope used in former experiments. [See Abstracts Nos. 452 and 1049 (1902).] The metals Au, Ag, and Pt are deposited chemically, and by means of kathode rays on quartz plates, and the thickness (d) of the layer determined by weighing, or by a chemical method. A table of values is given of the coefficients of absorption (a) and of extinction (g), these being calculated from: Intensity after transmission = intens. before $\times 10^{-ad}$, and $g = a\lambda/4\pi M$, where M is the log. modulus. For equal thicknesses gold is the most transparent to visible rays, platinum the most absorbent. Silver has a maximum transparency for $\lambda = 0{\cdot}321\ \mu$, when it is 1,200 times as transparent as platinum. The results for silver are compared with those of Jamin, Quincke, Drude, and Wernicke, those for silver deposited by kathode rays agreeing with Wernicke's results. The numbers for chemically deposited silver are somewhat larger. The indices of refraction are calculated from the reflecting power and the extinction coefficient. The sequence of the metals as regards absorption is the same as for electric conductivity. G. E. A.

1676. *Optical Properties of Asphalt.* **E. L. Nichols.** (Phys. Rev. 14. pp. 204–213, April, 1902.)—In the first set of observations a thin layer of asphalt was obtained by dipping a piece of plate glass in asphaltum varnish and allowing it to dry. A one-prism spectroscope was used, and comparisons of the absorption spectra obtained from similar acetylene flames, through the glass alone, and through the glass and varnish, were made. The extinction coefficients for wave-lengths from 7,300 to 5,890 Ångstroms, were thus obtained, and a transmission curve for the visible spectrum is shown. An almost complete opacity in the yellow is found. The layer used here was about 0·003 cm. in thickness, but by another method of preparation a layer 0·00005 cm. thick was obtained, and this gave similar results. To determine the dispersion of asphalt, a prism of angle 1° 50′ 2″ was made. This was examined by a two-prism spectrometer, and the indices of refraction for several wave-lengths were found.

Measurements in the infra-red were made by a Nichols radiometer, the deflections being taken first with the radiometer exposed to the absorption spectra, secondly to the spectrum of the uninterrupted rays from the flame. The author concludes that these optical properties may be due to particles of carbon dissolved or suspended in the medium of the varnish. There are, however, on the other hand, many differences between the optical behaviour of asphalt and carbon. J. W. P.

1677. *The Influence of the Atomic Weight on the Absorption, Dispersion, and Colour of Transparent Bodies.* **F. F. Martens.** (Deutsch. Phys. Gesell., Verh. 4. 8. pp. 138–166, April 25, 1902.)—For the present purpose the author

used, in almost all cases, the method already described by him. [See Abstract No. 302 (1902).] An examination of the data given in the paper here presented leads to the following general conclusions :—

(1) For a number of transparent non-conducting elements (C, P, S, Cl, Se, Br, I), the wave-length corresponding to the principal absorption band in the ultraviolet is approximately proportional to the square root of the atomic weight; this wave-length is independent of the state of aggregation of the element, and is unchanged in solution. (2) The absorption band, λ, of an element A such as those mentioned, remains nearly unaltered when A combines chemically with another element B; there occurs usually, however, some little displacement of λ, but this displacement appears to be the less, the more A atoms there are in the molecule. (3) The metals, in their transparent compounds, give rise to characteristic absorption bands, which appear more in the region of longer waves as the atomic weight of the metal increases. D. H. J.

1678. *Photophonic Books for the Blind.* **V. de Turine.** (Écl. Électr. 31. pp. 16–19, April 5, 1902.)—A sheet of transparent paper contains, printed upon a black background, a number of small white squares, separated from each other by intervals one, two, or more lengths of a square in size. These squares, together with the intervals, represent the letters of the alphabet, exactly as do the dots and dashes of Morse. In order to enable the blind to read these letters, the printed sheet is placed in a frame between two thin plates of glass fully exposed to the light, and an opaque piece of cardboard, or some other material, with a square-shaped opening in the centre, is moved by the reader along the printed lines from left to right. Whenever the opening passes over one of the white transparent squares, the rays of light illuminating the printed sheet pass through this opening, and, by means of a photophonic apparatus, are changed into sound. In this way, the blind reader receives the letters in the form of sounds separated by longer or shorter intervals of silence, and his ear fulfils the functions of the eye. There exists a great variety of photophonic devices that can be used for transforming the rays of light into sound for the purpose above stated. Thus the light may be made to impinge upon a plate of selenium intercalated into a circuit fed by a galvanic battery, so that whenever the light falls upon the selenium and permits the currents to pass through it, a slight sound is caused in an electromagnetic apparatus attached to the circuit. Or a Wheatstone bridge may be used, fed by an alternating or intermittent current, the generator of which is situated in one of the diagonals, while the other contains a telephone, and a plate of selenium is intercalated in one of the branches, the bridge being so balanced that the telephone remains silent as long as no light falls upon the selenium, while the moment that the latter is illuminated it emits a sound. In a third method a differential telephone fed by alternating or intermittent currents is used, which, in one of its circuits, contains a plate of selenium; the two circuits being so balanced that the currents neutralise each other, and no sound is heard as long as no rays of light impinge upon the selenium. These methods and many similar ones will be quite suitable for the desired object. Instead of photophonic devices based on the characteristic qualities of selenium, others may be used resembling the apparatus of Mercadier, in which the diaphragm of a microphone is covered with lamp-black and serves as the bottom of an air-tight box, the cover of which is a glass plate. The microphone is intercalated in the circuit of a galvanic battery, which also contains the primary of an induction coil, the secondary of which is connected

with a telephone. The light falling upon the blackened diaphragm produces, as in the case of selenium, the conditions required for the absence of sound in the telephone. G. G.

1679. *Photography applied to Architectural Measurement and Surveying.* **J. B. Lee.** (Soc. Arts, Journ. 50. pp. 493–503; Discussion, pp. 503–504, April 18, 1902.)—Starting from the geometrical relationship between objects and the images of those objects, the author shows that by knowing the station points from which the picture was taken, marking the horizontal and the vertical picture plane on each print, marking the orientations, and knowing the distance lines of the perspective, it is possible very readily to compare photographs from different standpoints so as to plot ground plans and estimate altitudes from these alone. Trafalgar Square is used as a practical illustration, with diagrams. A. D.

1680. *Rotation of Polarisation Plane in Moving Bodies.* **H. A. Lorentz.** (Konink. Akad. Wetensch. Amsterdam, Versl. 10. pp. 793–804, March 29, 1902.)—In his "Versuch einer Theorie, &c.," the author gives for the rotation of the polarisation plane per unit of length the following formula, $\omega = 2\pi n'^2 j/\sigma^2$, for the case of the medium being at rest, and—

$$\omega = \frac{2\pi}{\delta^2} n'^2 \left(1 + \frac{W g_x}{c^2}\right) j + \frac{2\pi}{\sigma^2} n'^2 W g_x k,$$

for the case of a translation in the direction of the x-axis, the light travelling in the same direction. In these formulæ, n' is the frequency for an observer taking a part in the translation, W the mean velocity of circularly polarised light in the stationary medium, c the velocity of light in the ether. Now, J. Larmor ("Ether and Matter," Cambridge, 1900), having opposed those deductions, the author proceeds to revise his theory. In this paper it is shown that Larmor's statements of the non-existence of an influence of a translation on the rotation of the polarisation plane are erroneous, the disagreement arising from an error in Larmor's calculations. It is shown that the equations of both will become identical for $k = 0$. A. G.

1681. *Magnetic Rotatory Powers of Ring Compounds; Camphor, Limonene Carvene, Pinene and their Derivatives.* **W. H. Perkin, Sen.** (Chem. Soc., Journ. 81. and 82. pp. 292–318, April, 1902.)—Saturated closed chain or ring compounds—such as tri-, tetra-, penta- and hexa-methylene derivatives—have a much lower magnetic rotation than those having unsaturated open chains, but the same composition; their rotations are also smaller than those of the saturated open chain compounds, from which they differ in composition by H_2. On comparing the rotations of the mono- and di-carboxylic acids and ketones of the closed chain compounds with those of the corresponding saturated open chain aliphatic compounds, it is found that, if tri-, tetra-, penta- and hexa-methylene be taken as the first, second, third and fourth members of the series, and be compared with the corresponding members of the aliphatic series, the differences between the rotations of the two series are then nearly uniform, and amount to about −0·60 in the mono- and di-carboxylic acids, ketones and monochloro-derivatives of hexamethylene; in the ring hydrocarbons, this difference is, however, much larger, amounting to about 0·988. As regards the influence on the rotation of a double or bridged ring compound, in which the ring formation from the open chain compound has taken place twice, and hence with the loss of four hydrogen

atoms, this, in the case of camphor, is —1·290, and in camphene, —1·337, these numbers being slightly greater than that for a single ring; borneol and pinene give similar results. For the limonenes, which are isomeric with camphene, but contain only a single unsaturated ring along with the group, $-C(CH_3):CH_2$, outside the ring, the rotations are very different, the value of the single ring formation, allowing for unsaturation, being practically the same as in hexamethylene, 0·988. The rotations of some other derivatives are also considered. T. H. P.

1682. *Rotatory Powers of the Esters of Stable Lævo-Borneol.* **J. Minguin** and **E. G. de Bollemont.** (Comptes Rendus, 134. pp. 608–610, March 10, 1902.)—The results are given of measurements of the specific rotatory powers of a number of bornyl esters prepared from the stable lævo-borneol. The transformation of the borneol into its formic ester is accompanied by a change in the $[\alpha]_D$ from —38·09 to —49; the absolute value of this magnitude then goes on gradually decreasing as the molecular weight of the ester increases. For the series, formate, acetate, propionate, butyrate, isobutyrate, valerate, and laurate of bornyl, it is found that the specific rotation is approximately inversely proportional to the molecular weight. The various haloid derivatives of those fatty esters examined also obey a similar law, but the product of specific rotation and molecular weight is not the same for the two series. T. H. P.

1683. *Radiation of Mercury in the Magnetic Field.* **C. Runge** and **F. Paschen.** (Astrophys. Journ. 15. pp. 235–251, May, 1902.)—This important paper consists chiefly of the numerical results of an investigation on the lines of the mercury spectrum, to trace the connection between the Zeeman effect of the magnetic field and the distribution of the lines in series. It was carried out on lines whose wave-length comes between 5,460 and 2,534. The observations support the conclusions of T. Preston [Nature, 59. 248 (1899)]. They show that at different field strengths the distances of separation of the components of a line remain in proportion, so that only the scale of the image increases with the field strength. This rule enables the authors to reduce all their measurements to the same field strength. An exception to this appears to occur in the case of a few fainter components of the stronger lines. This the authors attribute to satellites which lie very near to the lines under consideration without the magnetic field. It is further shown that the increase of the scale of separation, with rising field strength, is always in the same ratio for all lines of the spectrum. As far as the accuracy of the measures permits, lines of the same series (*i.e.*, lines which are represented by the same empirical formula of Kayser and Runge, or of Rydberg), exhibit the same separation due to the magnetic field, in the sense that, according to the scale of vibration numbers, the components of all the series lines have the same distances, and that corresponding components are also polarised in the same way. R. S. W.

1684. *Banded Spectra of Nitrogen.* **H. Deslandres.** (Comptes Rendus, 134. pp. 747–750, April 1, 1902.)—In previous papers the author has pointed out that the radiations of a group of bands belonging to one spectrum can be represented by a formula of the form $N = e\,f\,(n^2, p^2) \times m^2 + Bn^2 + \phi\,(p^2)$, where m, n, and p are successive whole numbers, B a constant, and f and ϕ characteristic functions of the particular substance. Cuthbertson [see Abstract No. 1517 (1902)] has published a table showing the distribution of

forty bands in the first group in the positive band spectrum of nitrogen, in which he defines thirteen series. In this table, however, there are two exceptions, namely the bands with heads at 16,319 and 16,474. If, however, fifteen series be defined, then these two bands fall into line as well as two new, rather weak bands at 14,729 and 16,319, measured by Thalen. The author further points out that in Cuthbertson's table, not only do the horizontal intervals form an arithmetical progression with a difference of 30·319, but the vertical intervals also form an arithmetical progression with a difference of 29·363. The combination of these two series gives the arithmetical progression diagonally across the table with variable differences. It follows from this that in the above general formula the function $\phi(p^2)$ assumes for the first group of bands the simple form $D + Cp^2$, so that the 42 heads of bands can be represented by the expression—

$$N = 22785{\cdot}1 - \frac{30{\cdot}319}{8}(2n)^2 + \frac{29{\cdot}363}{8}(2p+1)^2.$$

A table of frequencies is given, showing the values observed and those calculated from the formula, with an extremely good agreement between the two. The distribution of the component rays of each band, or the function $f(n^2p^2) \times m^2$ still remains to be determined, about which little is known, owing to the difficulty of examining the bands under high dispersion. In the second and third groups the bands form a series, with exactly the same difference as is observed in the second series above, namely, 29·363. Similar series are to be observed in other banded spectra, *e.g.*, carbon, and the differences are characteristic constants appertaining to each individual substance.

E. C. C. B.

1685. *Spectra, Densities, and Melting-points of some Groups of Elements.* **H. Ramage.** (Roy. Soc., Proc. 70. pp. 1–27. May 12, 1902.)—Corresponding lines are selected from the spectra of certain groups of metals, and their oscillation frequencies plotted against the atomic masses of the elements, in one diagram, and in a second, against the squares of the atomic masses. The lines drawn through the corresponding points on the diagrams show well the fact that the metals may be classified into groups by their spectra. These lines also show certain breaks, *e.g.*, between sodium and potassium in the alkali group, and in other cases. It is noteworthy that a decided break occurs in the lines drawn through the nebulous series of the aluminium group, while for the sharp series the break is insignificant. The densities and melting-points of the same elements were plotted in a similar way, and from these diagrams interesting analogies are to be noted with the spectra diagrams, particularly in the case of the aluminium group, for the density and melting-point curves are analogous to the curves of the diffuse series of spectrum lines, so that all three would seem to have their origin in the same fundamental cause.

E. C. C. B.

1686. *Measurements of Certain Absorption Spectra.* **G. Laubenthal.** (Ann. d. Physik, 7. 4. pp. 851–861, April 8, 1902. Abstract from the Bonn Dissertation.)—Measurements were made in various ways of the bands in the absorption spectra of the lakes formed by alkannin and certain metallic salt solutions. The salts used were the chlorides of the alkali metals and the metals of the alkaline earths. The means of the measurements of the various bands are given, and it is pointed out that, in the case of each of the two groups studied, the bands shift towards the red with increasing atomic weights,

and that the shifts are proportional, so that the ratio between the wave-lengths of the two bands of each spectrum is constant for each group of metals. [Although the author's conclusions are based on somewhat scanty data, they are materially strengthened by the facts given in Ramage's paper. (See preceding Abstract.) If the wave-lengths of the absorption bands are plotted against atomic weights in a similar way to Ramage's method, the curves have almost identical shapes with those given in Ramage's paper for the same groups of metals. The same break occurs between sodium and potassium, and probably a similar break in the beryllium to calcium curve, but Ramage does not include beryllium. This is extremely interesting, inasmuch as the absorption spectra are thus brought into line with the emission spectra, and also the densities and melting-points, as having their origin in the same fundamental cause.] E. C. C. B.

1687. *Discrepancy between Grating and Interference Measurements.* **L. Bell.** (Astrophys. Journ. 15. pp. 157–171, April, 1902.)—The paper consists of a discussion of the relative value of absolute wave-lengths as determined by the grating and by Michelson's method, there being, between the values for D_1, as obtained by the two methods, a difference of 0·19 tenth metre. After considering the great sources of error in measurements made with the grating, the author concludes that as a means of absolute measurement the grating is not to be compared with the interference method. At the same time he points out that Michelson's measurements should be independently repeated in order to show their practical limits of error, and also is of the opinion that in the present state of our knowledge no measurement can be trusted to within 0·01 tenth metre. Future work should, he says, be addressed to the questions of shifts of lines under pressure changes, and of the constancy of wave-length in the solar lines, following up Jewell's preliminary paper. [Astrophys. Journ. 3. 89 (1896).] E. C. C. B.

1688. *Multiple Transmission Fixed-arm Spectroscopes.* **W. Cassie.** (Phil. Mag. 3. pp. 449–457, April, 1902. Paper read before the Physical Society, Nov. 22, 1901.)—Four designs of the multiple transmission spectroscope are described, which are alike, in so far that they all have the telescope and collimator in the same vertical plane, with the former at a higher level than the latter, but differ in their arrangements of the prisms. In the first design two equal half-prisms are used which are silvered at the back. One of these half-prisms is placed just below the telescope lens and the other just above the collimating lens, and the light from the collimator thus falls upon the lower part of the first prism. Being at minimum deviation, the light is refracted and then normally reflected at the silvered face, and thus passes out of the prism. The prism is inclined at such an angle as to direct the emergent ray into the lower portion of the second half-prism, where the same process takes place; the light is thus reflected backwards and forwards until finally it passes over the top of the first prism into the telescope. The two half-prisms are mounted on revolving tables which are simultaneously turned by an endless screw, by which means various portions of the spectrum can be examined. In the second design the rays from the collimator pass through an ordinary 60° prism, and then fall normally upon a plane mirror which reflects them back through the prism normally on to a second mirror. By slightly inclining the mirrors, the beam of light in its passage backwards and forwards continually rises until it passes over the prism into the telescope. In the third form two half-prisms are again employed, and are set close

together in the same horizontal plane, with their hypoteneuses facing one another, and their apices pointing towards the collimator. The beam from the collimator falls on the outer face of the first prism, and is there refracted, and then totally reflected out into the second prism, where it is first totally reflected, and then refracted back towards the collimator, parallel to its first path. By means of a right-angled prism, the ray is twice totally reflected and directed again into the first prism. The prisms are again so adjusted that after several cycles the rays pass over the refracting prisms into the telescope. The fourth design is described in an addendum, and consists of a single half-prism with a right-angle prism cemented to the back, with its edge at right angles to the refracting edge of the half-prism. The beam from the collimator passes between two right-angle prisms set near together, and then enters the half prism just below the centre; it is then totally reflected back again through the half-prism, and leaves it a little higher than it went in. By means of the two right-angled prisms by the collimator, the rays are again directed into the half-prism below their last entry, and thus, on again leaving the half-prism, they are higher than before. After several cycles, the rays pass under the combination prism into the telescope. The author considers the last to be the best instrument because of least light being lost by reflection, and because it possesses full resolving power. E. C. C. B.

1689. *The New Gas from Radium.* **E. Rutherford** and **Miss H. T. Brooks.** (Chem. News, 85. pp. 196–197, April 25, 1902. From Transactions of the Royal Society of Canada, Ser. 2. 7. p. 21.)—The greater part of this paper treats of investigations previously dealt with. [See Abstract No. 2110 (1901).] The authors observe that the emanation there referred to is most remarkable, as it not only continues for long intervals to be a source of radiation which is apparently similar to easily absorbed Röntgen rays, but it in some way manufactures from itself a positively charged substance, which travels to the negative electrode and becomes a source of secondary radio-activity. J. J. S.

REFERENCES.

1690. *Pressure of Heat and Light Radiation.* **E. F. Nichols** and **G. F. Hull.** (Phys. Rev. 13. pp. 307–320, Nov., 1901.)—A preliminary communication.

1691. *Astigmatic Refraction through a Sphere.* **L. Matthiessen.** (Ann. d. Physik, 7. 2. pp. 381–389, Feb., 1902.)—A mathematical treatment of the case of oblique incidence through a sphere, starting from Reusch's equations for conjugate points of a beam incident obliquely on a spherical surface. G. E. A.

1692. *Electrical and Optical Phenomena of Moving Bodies.* **H. A. Lorentz.** (Archives Néerlandaises, 7. pp. 64–80, 1902.)—This is a French translation from the Kong. Akad. Wetensch. Verslagen, Amsterdam, 1899. G. W. DE T.

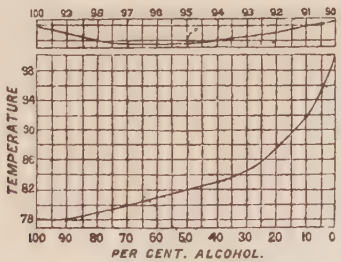
1693. *Radio-activity Imparted by Kathode Rays.* **J. C. McLennan.** (Phil. Mag. 3. pp. 195–203, Feb., 1902.)—A paper on the same lines as that dealt with in Abstract No. 42 (1902).

1694. *Optotechnics.* **S. P. Thompson.** (Soc. Arts, Journ. 50. pp. 518–527; Discussion, pp. 527–530, April 25, 1902.)—This is a paper outlining the essentials of optotechnical training, and advocating, in the interests of the British optical industry, the establishment of an optotechnical educational institute. G. W. DE T.

HEAT.

1695. *A Thermoregulator.* **T. S. Patterson.** (Soc. Chem. Ind., Journ. 21. pp. 456–457; Discussion, p. 457, April 15, 1902.)—The author describes a modification of d'Arsonval's thermoregulator. The tube connected with the gas supply terminates just above a rubber drum stretched over the tube containing the supply of mercury or other expansible fluid. When the mercury expands, it causes the rubber drum to bulge out, and, wholly or partly, cut off the supply of gas. The mercury tube is connected with a side-tube containing a tap, to enable the amount of mercury in the apparatus to be regulated; the apparatus may therefore be adjusted for use at any part of the thermometric scale. D. H. J

1696. *Boiling-point Curve for Mixtures of Ethyl Alcohol and Water.* **W. A. Noyes** and **R. R. Warfel.** (Chem. News, 85. pp. 185–186, April 18, 1902. From the Journ. Amer. Chem. Soc. 23. No. 7.)—According to Le Bel, 98 per cent. alcohol yields on fractionation a distillate of 97·4 per cent. strength by volume, and a residue of 99·5 per cent., implying that the boiling-point of absolute is higher than that of slightly diluted alcohol. To verify this, the authors have determined the boiling-points of a large number of



mixtures, avoiding entrance of moisture during distillation by sealing the condenser to the side tube of H. C. Jones's apparatus, protected above by a calcium chloride bulb. Alcohol of a gravity indicating 99·98 per cent. was obtained by boiling twice with lime, adding the second time a little barium oxide. Several series of determinations were made, and the results calculated by interpolation for each half per cent., and plotted in the accompanying curve. The upper part gives the boiling-points between 90 and 100 per cent. on an enlarged scale; the lower portion is the complete curve. The minimum boiling-point occurs with alcohol of 96 per cent. by weight, while that of 90·7 per cent. has the same boiling-point as absolute alcohol. S. R.

1697. *Boyle's Law for Pressures of 75 and 150 mm. of Mercury.* **Rayleigh.** (Roy. Soc., Phil. Trans. 198. pp. 417–430, April 12, 1902. Roy. Soc., Proc. 69. p. 495, April 4, 1902 (Abstract).)—A special gauge was made by joining together two cylindrical glass chambers, one vertically above the other, by a short neck, cementing in this neck (and so completely blocking it) a glass rod, with its ends carefully pointed, and the upper one bent downwards so as to be 75 mm. from the other, connecting the bottoms of the chambers by a narrow tube C, continuing the upper chamber upward and the lower

chamber downward by narrow tubes H, I, and connecting a narrow tube G to the top of the lower chamber. If then, by means of H, mercury is sucked up I, so as to fill C and touch both ends of the rod, the gas entering the lower chamber by G must be of higher pressure than that in H by 75 mm. of mercury. Two such gauges were employed which, as determined by testing them in parallel, indicated pressures in the ratio of 1 : 0·99862. A volume of gas was taken with the pressure indicated by one of these gauges, and it was then compressed till the pressure was that of the two in series, its new volume being noted: and it was found that, to an accuracy of $\frac{1}{3000}$, air, hydrogen, oxygen, and argon obey Boyle's law at the pressures and temperatures (10°–15° C.) of the experiments, while nitrous oxide deviates from it in having greater compressibility. R. E. B.

1698. *Atomic Weight and Specific Heat of Vanadium.* **C. Matignon** and **E. Monnet.** (Comptes Rendus, 134. pp. 542–545, March 3, 1902.)—The specific heat of vanadium has not been determined up to the present. The authors have rectified this omission by determining the specific heats of alloys of vanadium with aluminium and with iron, and thence deducing the specific heat of the vanadium alone by applying the law of Regnault to the alloys. The vanadium iron gave for vanadium the specific heat 0·1258, and the atomic heat 6·4, for temperatures between 15° and 100°; the vanadium-aluminium gave for the vanadium the specific heat 0·1235, and atomic heat 6·3. D. H. J.

1699. *Isothermals of Di-atomic Gases and their Mixtures. II., III., and IV.* **H. Kamerlingh Onnes** and **H. H. F. Hyndman.** (Konink. Akad. Wetensch. Amsterdam, Verslag 10. pp. 809–829, March 29, 1902.)—In the first of this series of papers the determination of densities by means of the piëzometer, in the case of variable volume and low temperatures, is discussed, full particulars being given with regard to observations and the calculation of results. In the second paper the isothermals of oxygen are given for the temperatures of 20·0°, 15·6° and 0° C., in order to have reliable data for pressures inferior to 100 atmospheres, Amagat's experiments extending only over very high pressures. By means of the results of these determinations, the coefficients for oxygen in the series developed by the authors in a preceding article can be corrected, and the corrections accounting for temperature differences may be effected, with values taken from the authors' own work. In the third article the compressibility of hydrogen at 0° and 20° is investigated with the piëzometer, for variable volumes and low temperatures, in order to test this method on Schalkwijk's results, this comparison being so satisfactory as to warrant the reliability of the determinations made for oxygen. A. G.

1700. *High Temperatures and the Law of Stefan.* **Féry.** (Comptes Rendus, 134. pp. 977–980, April 28, 1902.)—The principle of the apparatus here described is to place near the body whose (high) temperature is to be measured, another suitably chosen body, and from the temperature elevation of the latter due to radiation, calculate by Stefan's law the temperature of the former. The arrangement used consists of a lens to concentrate the heat rays, and a thermo-electric couple of iron and constantan connected up to a galvanometer. A comparison is made of results from this instrument in conjunction with Stefan's law, and results from a Le Chatelier pyrometer, for temperatures from 840° to 1,450°. The difference is in all cases less than 1 per cent. This method gives 3,490° as the temperature of the positive carbon of the electric arc. J. W. P.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

1701. *Effect on Charged Condenser of Motion through the Ether.* **F. T. Trouton.** (Roy. Dublin Soc., Trans. 7. pp. 379–384, April, 1902.)—Fitzgerald, in 1900, suggested that a charged condenser moving through the ether with its plates edgeways to the direction of motion should possess a magnetic field between the plates, in consequence of the motion. If, therefore, the earth is moving through the ether, a condenser placed with its plates edgeways to the direction of the relative motion should, provided the energy required to establish this field be derived from the charging source, experience a drag during charge and a forward impulse during discharge. Preliminary experiments made by the author with a delicately suspended condenser during Fitzgerald's lifetime gave only negative results, and the latter expressed the opinion that, if these were confirmed, they were to be attributed to a diminution of the electrostatic energy of the condenser when in the edgewise position, due to the dimensional changes arising from the motion through the ether by which Lorentz and himself had explained the negative results obtained in the Michelson-Morley experiment. The author has since perfected the apparatus, using a condenser in which the drag-impulse would have a kinetic energy of about an erg, while, by timing the impulses so as to tend to set up a swing, an impulse of kinetic energy 0·004 erg would produce observable effects. No effect, however, could be detected. The author points out that, if the energy for the magnetic field when moving edgeways is supplied by the charging source, there must be a continuous turning movement tending to set the condenser flatways to the direction of motion relative to the ether. He proposes to experiment with a view of finding such an effect, and observes that such experiments would not be complicated by the relay arrangements which had to be employed to prevent sparking during the intermittent charging at the high p.d. of 1,200 volts which was employed.

G. W. DE T.

1702. *Crémieu's Experiments and Wilson's Objection.* **A. Potier** and **H. Poincaré.** (Écl. Électr. 31. pp. 83–93, April 19, 1902.)—Wilson has stated that Crémieu's results, instead of being contrary to the accepted theory, are really an indirect corroboration of it, as the effect of convection-currents should be opposed and balanced by that of conduction-currents in the screen separating the astatic apparatus from the rotating disc. In the present article there is published some correspondence on the Crémieu experiments, which passed between MM. Potier and Poincaré some time ago (December 4, 1900–January 13, 1901). In this correspondence the theoretical conditions of the problem are discussed, and the influence of the screen and of conduction-currents comes under consideration. Both writers are agreed that the effect of conduction-currents is *nil*. Considering the case of two circular metallic discs, D and D′, with an electrified mass M rotating between them—M inducing on D and D′ electric charges which rotate with it—Poincaré agrees that there is a strong conduction-current in the direction in which the disc rotates, but there is also, he says, a weak conduction-current right round the disc in the opposite direction. This current is weaker than

the other, but it is longer ; at each point of the disc it lasts longer than the strong current, so that there is a balance, and the mean current is zero. [See also Abstracts Nos. 1666 (1900), 144, 858, 1100, 1303, 2139 (1901).] W. C. H.

1703. *Duration of Charge and Deformation of Condensers.* **G. Ercolini.** (N. Cimento, 3. pp. 353–372, May, 1902.)—The deformation of condensers increases with the time of charge, except that in the first moments it remains constant, in general, for a time which is longer the greater the potential ; the increase of deformation diminishes with the duration of the charge. Discharge does not restore a condenser to its original condition ; the residual deformation increases when the potential, or the duration of the charge, increases. After a certain time, always short, the condenser returns to the original condition, passes it, and remains deformed for a long time, never less than, say, five minutes. Under potentials maintained constant, the deformations are less than those under rising potentials. During charge or discharge there is an exchange of heat energy between the condenser and its environment, and there is a change in the thermic capacity of the condenser, which diminishes as the difference of potential between its plates increases. These two phenomena tend to produce opposite variations of temperature. The slower the charging the more the condenser cools down. A. D.

1704. *Lightning Above and Below Water.* **J. Trowbridge.** (Scientific American, 86. p. 239, April 5, 1902.)—The author describes experiments which lead him to the conclusion that lightning never strikes the surface of the sea. When a lightning discharge seems to do so, it really passes from one region of the air to another, and it is only perspective which leads one to suppose that it strikes the water. The author has often endeavoured to pass powerful sparks to the surface of water, in order to obtain a strong spectrum of water vapour, but in every case the sparks—6 in. in length, and resembling lightning discharges as far as possible—refused to strike the level surface of the water and pass to the edges of the containing vessel. In a vacuum tube with water terminals and exhausted to the vapour tension of water, no discharge could be made to pass from one water-surface to the other. It is also very difficult to pass powerful sparks from one stream of water to another, and the author thinks it improbable that lightning discharges pass through regions in the air of heavy rainfall. In his endeavours to obtain a good water-vapour spectrum, the author set himself to produce an electric spark under water. Using distilled water, it was necessary to use platinum wires sealed in glass tubes, and emerging not more than half an inch. If the terminals are dipped to a depth of 2 in. in the water, the containing tube, if not more than 2 in. in diameter, is shattered by the sparks. If the terminals are only dipped to a small depth in the water, a spark passes giving a very brilliant light resembling that of an enclosed arc lamp, but having no lines in its spectrum. This spectrum is probably due to water vapour, and the different spectra of lightning obtained by different observers are due to different amounts of water vapour in the air. Zigzag lightning occurs in the lower regions of the atmosphere, certainly below 1,000 ft. ; above 1,000 ft. it loses its zigzag character, and can be of great length with the same voltages as in lower altitudes. At still higher regions we have the aurora. Water vapour plays a controlling part in all these phases of lightning. W. C. H.

1705. *Annual Periodicity of Auroräs.* **C. Nordmann.** (Comptes Rendus, 134. pp. 750–752, April 1, 1902.)—The author offers an explanation for the

well-known fact that in the middle latitudes there is a double annual periodicity in the frequency of northern lights, the maximum occurring at the time of the equinoxes, and the minimum at that of the solstices. He does not enter upon a discussion of the causes to which the phenomenon of the aurora borealis is due, he merely takes for granted that the sun plays a part in its production, and that the shorter the time that the atmosphere has been deprived of the action of the solar rays, the greater is the intensity of the auroras. This is shown in their diurnal variations, by the fact that their greatest frequency coincides with the early evening hours. The same interdependence of the frequency of northern lights, and the saturation of the atmosphere by sunlight is perceptible in the annual periodicity. At the time of the equinoxes, that terrestrial great circle which divides day from night has a position perpendicular to the equator, *i.e.*, to the plane of the earth's rotation, while at the time of the solstices it has an inclination toward the latter of $90° - 23° 27' = 66° 33'$. The isolated portion of the atmosphere, therefore, which during a given time t passes from day into night, *i.e.*, from one side of the dividing circle to the other, occupies alongside this circle an area, the width of which at the moment of the equinoxes is l, while at the moment of the solstices it is $l \times \sin 66° 33' = l \times 0{\cdot}9$, l being the arc through which the earth rotates during the time t. Other things being equal, therefore, 10 auroras at the period of the equinoxes correspond to 9 at the solstices. This difference is rendered still greater by the twilight which reigns in a part of the atmosphere bordering on the dividing greatest circle and having a width equal to $\frac{l}{n}$. In this area the auroras are not yet visible, its illumination being still too bright, while at the same time the efficiency of the sun's rays in the production of auroras is no longer sufficiently great to be taken into account. If l therefore represents the width of the atmospheric area, counting from the dividing circle, in which the greater number of auroras occurs after sunset (the number of those occurring in atmospheric regions plunged into greater darkness compared with the latter is insignificant), the difference in the frequency of auroras at the two periods mentioned is represented by the formula $r = (l \times 0{\cdot}9 - l/n)/(l - l/n)$, which is smaller than $(l \times 0{\cdot}9)/l$. Assuming, for instance, that n equals N, we get $r = 0{\cdot}8$, which means that eight auroras at the periods of the solstices correspond to ten at the equinoxes, which agrees with the observed differences. Nevertheless this value is only approximately correct. To render it more accurate, the facts must be taken into account (1) that the number of auroras, counting from the moment of sunset, does not grow as fast as at the time counting from the same starting-point (*i.e.*, their number is greater during the first hour than during the next), and (2) that the time r, intervening between the moment of sunset and the end of twilight, is shorter at the period of the equinox than at that of the solstice. By so doing it will be seen that the value for r is still smaller than that given above, *i.e.*, that the difference in the frequency of auroras at the two periods stated is still greater than that above mentioned. G. G.

1706. *Electric Potential of the Atmosphere on Spitzbergen and Juist.* **J. Elster.** (Terrestrial Magnetism, 7. pp. 9–15, March, 1902.)—The observations made in Virgohafen on Spitzbergen in the summer of 1900, gave a low potential gradient and a high conductivity of the air (five times the average value for the Continent of Europe). On the island of Juist (near Borkum, the North Sea), the conductivity was found normal in summer, 1901, but

the potential gradient very high, especially with winds from the sea. According to Lenard and Kelvin, the positive charge of the air is largely due to the salt-water spray produced by breakers; but the distance of the flame-collector from the breakers made no difference in Heligoland, where the experiments were continued under more convenient conditions. H. B.

DISCHARGE AND OSCILLATIONS.

1707. *Rise of Pressure on Breaking a Circuit with Capacity.* **G. C. Garrard.** (Elect. Rev. 50. p. 572, April 4, 1902.)—A quarter-mile length of high-tension, lead-covered, 7/20 concentric cable was connected, between the inner and outer, with a 4,000-volt supply, a horn arcing-switch, and a Ferranti oil-switch. At the other end of the cable a spark-gap was connected between the inner and outer conductors, which was set so as just not to spark over with the normal pressure. When the capacity current was broken with the arcing switch, the air-gap invariably sparked over, but when broken by the oil-switch, where practically no arc was formed, no spark passed. The author concludes that a non-arcing switch is of advantage in preventing rise of pressure in the circuit. G. H. B.

1708. *The Recombination of Ions in Gases.* **P. Langevin.** (Comptes Rendus, 134. pp. 533–536, March 3, 1902.)—The author has already indicated the principle of the method by which he has directly measured the ratio $\varepsilon = \frac{\alpha}{4\pi(k_1 + k_2)}$, where α represents the coefficient of recombination of the ions, k_1 and k_2 the mobilities of these ions in an electric field. [See Abstract No. 1558. (1902).] The ratio of the number of recombinations to the number of collisions between ions of contrary signs is also represented by ε, which must, therefore, always be less than unity. The experimental method consists in creating a uniform field in the gas contained between two parallel metallic laminæ and determining: (1) The quantity of electricity σ induced on one of these laminæ at the instant of the formation of the field; (2) the quantity of electricity Q collected by this lamina after the passage into the gas of the Röntgen rays proceeding from *a single discharge* in a Crookes' tube; (3) the quantity of electricity Q_0 liberated in the gas by the radiation, and that would be collected in an infinite field; the difference between Q and Q_0 being due to the recombination of the ions.

Theory indicates the following relation between these quantities, independent of the initial distribution of the ionisation in the gas—

$$\frac{\varepsilon Q}{\sigma} = \log\left(1 + \frac{\varepsilon Q_0}{\sigma}\right)$$

The quantity Q_0 not being obtainable directly was obtained from the measurement of the quantities Q and Q′ collected in two different fields produced by the charges σ and $\sigma' = m\sigma$. Details of the experimental arrangement are given, and although the thickness of the layer of gas, the field, and the distribution and intensity of the ionisation were caused to vary within wide limits, the values obtained for ε in dry air under atmospheric pressure at 17° remained between 0·26 and 0·28. The mean value 0·27 coincides with that which may be deduced from Townsend's determination of the coefficient of recombination α obtained by an entirely different method. There is thus in air a

normal pressure about one recombination in four collisions between ions of contrary signs. The ratio ε tends towards unity when the pressure increases. J. J. S.

1709. *The Mobility of the Ions in Gases.* **P. Langevin.** (Comptes Rendus, 134. pp. 646–649, March 17, 1902.)—The author explains how his method, described in a previous paper [see preceding Abstract], may be employed to measure the mobility of ions more directly and in more varied conditions than has been possible hitherto. This is due to the extremely short duration (about 10^{-4} seconds) of the single discharge of a coil through a Crookes' tube which is used in the experimental method. This method is further discussed in the paper, and the results obtained for different gases under different pressures are promised in a later communication. J. J. S.

1710. *An Induced Property of Ionised Air.* **F. Campanile** and **G. di Ciommo.** (Elettricista, Rome, 11. pp. 69–71, March, 1902.)—The authors have investigated the discharging effect of ionised air which has passed over the surface of a volatile liquid, as compared with that of the same ionised air after passing over a non-volatile liquid like glycerine. The ionised air in each case was made to impinge on the knob of a charged gold-leaf electroscope, which was observed during the experiment. The results are given in the following table :—

Experimental Liquids.	Length of Time for Discharge.	
	Positive Charge.	Negative Charge.
Glycerine	121·5″	133·5″
Alcohol	88·0″	97·0″
Glycerine	121·5″	129·7″
Water	107·0″	112·0″
Glycerine	109 0″	109·0″
Benzene	90·0″	95·0″
Glycerine	185·8″ (?)	149·6″
Chloroform	101·0″	109·0″
Glycerine	105·7″	113·0″
Carbon bisulphide ...	88·5″	92·0″
Glycerine	132·0″	111·5″
Turpentine	97·0″	81 0″
Glycerine	370·0″	285·0″
Petroleum	330·0″	243·0″

It is seen that the discharging effect of the ionised air is increased by the vapour of the volatile liquid. We may explain this increase (1) by assuming that the mingled vapour has a greater conductivity than the ionised air, or (2) by assuming that the mingled vapour is ionised. D. H. J.

1711. *Variation of the Spectrum of Sparks.* **B. Eginitis.** (Comptes Rendus, 134. pp. 824–825, April 14, 1902.)—When the spark terminals contain

different metals, variation of the self-induction of the circuit greatly affects the composition of the light given by the spark. Using terminals of aluminium wire coated at their ends with a small quantity of metallic sodium, the author finds that the spectrum of ordinary sparks passing between the terminals contains aluminium and sodium lines, but that when the self-induction of the circuit is increased, while keeping the resistance constant, the aluminium rays diminish very rapidly in intensity, while the yellow sodium rays become more and more intense. The aluminium rays are confined more and more to the neighbourhood of the terminals, and finally, when the self-induction is sufficiently increased, disappear altogether. The sparks are then of a brilliant orange colour, due to sodium vapour, and if the self-induction is still further increased, there comes a point at which the sodium line is reversed, aluminium being still absent from the spectrum. The same results are obtained with platinum, iron, tin, and some other metals, in place of aluminium. In some cases, *e.g.*, iron-sodium, the large values of self-induction make the iron rays reappear. Some metals, *e.g.*, Hg, K, or Na, can never be wholly eliminated from the spectrum. The peculiar behaviour of mercury leads the author to the general conclusion that the metals whose spectra are eliminated or diminished in intensity are metals which give small quantities of vapour, while those whose spectra persist or increase in intensity are among the very volatile metals. W. C. H.

1712. *Spark Discharge from Metallic Poles in Water.* **N. Lockyer.** (Astrophys. Journ. 15. pp. 190–198, April, 1902.)—Experiments were undertaken to test Wilsing's hypothesis that other causes, such as pressure, rather than motion in the line of sight, are the origin of the displacement and the doubling of the lines observed in the spectra of new stars. The discharge was produced by means of the Spottiswoode 42 in. spark coil with a condenser in the secondary circuit, so that the spark-length in water was about 0·5 mm. Although the photographs of the spectra of magnesium, iron, and zinc show reversals and shifts of position producing effects similar in appearance to the photographs of the spectra of new stars, the author concludes that the pairs of bright and dark lines in the latter cases are not due to the same cause as are the effects observed with the spark in water. This conclusion is based on the following reasons: while in the first place, in the case of the spark in water, the absorption lines are least and the emission lines most shifted, and in the new stars the opposite is the case, in the second place the shifts are very different in degree, being, for the absorption lines, in the one case small and in the other enormous. [See also Abstract No. 1539 (1902).] E. C. C. B.

1713. *Electric Oscillations in Distributing Networks.* **J. B. Pomey.** (Comptes Rendus, 134. pp. 696–697, March 24, 1902.)—In a network, oscillations could only occur through exchange of electric energy of condensers and magnetic energy of bobbins; but this is impossible. The strength of current takes the form $\Sigma C_\varepsilon \lambda_\tau$ where λ is negative, and there are no oscillations. A. D.

1714. *Duddell's Musical Arc.* **P. Janet.** (Comptes Rendus, 134. pp. 821–823, April 14, 1902.)—Let E be the e.m.f. of the battery of accumulators working the arc, R the resistance of the rheostat (without self-induction) in the main circuit, r the resistance of the derived circuit, L and C the self-inductance and capacity in this circuit, then $\omega = 2\pi \times \text{frequency} = 1/\sqrt{CL}$. Let I be the instantaneous value of the current in the main circuit, i that of

the current in the derived circuit, and i^1 in the arc. The main current I is evidently the superposition of a continuous current and an alternating current, whence $I = I_c + I_o \sin \omega t$. The potential difference at the terminals of the arc $V_A - V_B = E - RI_c - RI_o \sin \omega t$, also $i = \frac{R}{r} I_o \sin \omega t$, $i^1 = I_c + \frac{R+r}{r} I_o \sin \omega t$. Hence $d(V_A - V_B) = -RI_o\omega \cos \omega t dt$ and $di^1 = \frac{R+r}{r} I_o\omega \cos \omega t dt$. Therefore $d(V_A - V_B)/di^1 = -Rr/(R+r)$; consequently the differential coefficient of the potential difference at the terminals of the arc with respect to the current in the arc should be negative; this is the case with homogeneous carbons, even for oscillations of frequency from 1,000 to 10,000 per second. When r is small in comparison to R, $d(V_A - V_B)/di^1 = r$ numerically, that is to say, the apparent resistance of the arc should be numerically equal to that of the derived circuit. The paper then gives a table of the values of the instantaneous, effective, and mean currents, and the distribution of power in the different parts of the circuit. [See also Abstract No. 1098 (1902).] E. C. R.

1715. *Inductive Circuit with Harmonically-varying Resistance.* **T. Mizuno.** (Electrician, 49. p. 222, May 30, 1902.)—The author obtains an expression for the current in an inductive circuit whose inductance is constant, but whose resistance consists of a constant term and a harmonically varying one; the impressed e.m.f. is assumed to be constant. If the variation in the resistance is small and the frequency high, the circuit is almost indifferent to harmonic variation of the resistance. A. H.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1716. *Graduation of Thermo-electric Couples.* **D. Berthelot.** (Comptes Rendus, 134. pp. 983–985, April 28, 1902.)—Comparing the couples used for high temperatures, viz., platinum-palladium (Becquerel), platinum-platinum iridium (Tait, Barus), platinum-platinum rhodium (Le Chatélier), the author prefers the second, which is less costly, not less exact, and a little more sensitive than the others. A straight line law holds for the relationship between the logarithms of the electro-motive force and of the Centigrade temperature, the cold junction being at 0° C. and the range being 400° to 1,100°. For graduation it is therefore only necessary to find two fixed points, and if the range is to be 400° to 1,100°, the melting-points of zinc (419°) and of gold (1,064°) are recommended. Tables of figures showing agreement of directly observed results and those calculated from the graduation on the principles described, are given for a variety of temperatures. With a good galvanometer one should obtain without difficulty a sensibility of 0·1° in the vicinity of 1,000°. J. W. P.

1717. *The Induction Coil.* **J. Trowbridge.** (Phil. Mag. 3. pp. 393–396, April, 1902.)—The author finds that the performance of a powerful induction coil by Heinze, with a Heinze liquid interrupter, confirms Rayleigh's conclusions. [See Abstract No. 879 (1902).] The length of the iron of the primary coil is 48 in., its diameter 3½ in., and it is wound with one layer of No. 6 copper wire. The secondary coil consists of 140 sections of between 400 and 500 turns of fine wire separated by ⅛ in. glass plates, and having a total resistance of 246,600 ohms. They are not embedded in paraffin, so that any section can be replaced if damaged. When excited with five accumulator cells a 15-in. spark is obtained with a condenser in the primary and an

ordinary vibrating break, and a 30 in. one, of astonishing body, with the liquid interrupter and no condenser. The number of interruptions per minute can be varied from 60 to 5,000 by varying the speed of the motor which operates it. G. W. DE T.

1718. *A Self-recording Atmospheric Electroscope.* **G. le Cadet.** (Comptes Rendus, 134. pp. 745–747, April 1, 1902.)—With a view to electric measurements in conjunction with Janssen this summer, on the summit of Mont Blanc, the author has devised a self-registering electroscope, provided with a collector which is free from the objections that apply to water dropping, flame, and other usual collectors. The analogy which Elster and Geitel have shown to exist between the actions on gases, of flame, phosphorus, Röntgen and Becquerel rays, led the author to use a radio-active substance (a chloride of barium and radium) for the collector. The radium compound is placed in a closed rectangular box of aluminium, 5 cm. × 1·5 cm., placed at the end of an insulated brass rod, 2 m. long; such a box is transparent to Becquerel radiations, and may be used in wind and rain without detriment to its efficiency. The collector is attached to a calibrated electroscope or electrometer. By means of a beam of light passing through a very narrow slit, an image of the leaves of the electroscope is thrown on a horizontal photographic drum. D. H. J.

1719. *Ammeters and Voltmeters compensated for Variations in their Field.* **P. Weiss.** (Soc. Int. Élect., Bull. 2. pp. 266–275; Discussion, pp. 275–276, April, 1902.)—The paper describes the instruments constructed by Japy Frères & Cie, on the principle invented by the author [see Abstract No. 1525 (1901)], in which the controlling force of a d'Arsonval system is given by a small piece of soft iron, instead of by a spring, the controlling force thus varying with the strength of the permanent magnet. If the soft iron piece were always magnetised longitudinally, even when deflected, the curve between the strength of field and the current would be the curve of magnetisation of the soft iron; the actual curve deviates somewhat, as the direction of magnetisation of the soft iron does not turn exactly with the iron. The corresponding curve for a spring control proportional to the deflection is a rectangular hyperbola, and by combining the two controls, the current required to give a certain deflection can be made practically independent of the field. The instruments are constructed after the pattern of the Weston type with a silver spiral spring. A change in the magnet strength of from 570 to 670 makes less than 1 per cent. difference in the lower parts of the scale, and leaves the higher practically unaltered. On account of the small action of the control springs, the instruments are practically unaffected by variations in elasticity and by variations in temperature. The voltmeters are wound with manganin, and the deciamperemeters, which are used with shunts as ammeters, have a resistance of 1 ohm, of which half is of manganin. In reply to a question by **Arnoux**, the author stated that there was no difference in reading on an ascending and a descending curve. G. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

1720. *Harmonic Analysis of Waves by the Ondograph.* **E. Hospitalier.** (Ind. Élect. 11. pp. 150–153, April 10, 1902.)—The following simple methods of detecting the presence of harmonics in an alternating-current wave by

means of the ondograph [see Abstract No. 2172 (1901)], and of analysing the curve into its components are given. We can either use a large condenser (C), and trace its charging current by an ondograph, when the high harmonics will be shown magnified, and the current wave will present a very jagged appearance, or we can put a very large non-inductive resistance in series with an inductive coil, and apply the ondograph across the inductive coil, obtaining a curve which will show any high harmonics considerably magnified. The author then applies Pupin's Resonance method [see Abstract No. 1369 (1902)], and shows how, with the help of the ondograph, we can determine the magnitude and the phase of the various harmonics which form the actual wave. A. R.

1721. *Conductivity and Magnetic Properties of Iron Alloys.* **W. F. Barrett, W. Brown,** and **R. A. Hadfield.** (Inst. Elect. Engin., Journ. 31. pp. 674–721; Discussion, pp. 721–732, April, 1902.)—This is a very comprehensive research on some 110 alloys. The alloying elements are carbon, manganese, nickel, tungsten, aluminium, silicon, chromium, copper. The alloys are grouped in three classes according as they contain one, two, or three elements alloying with iron. The alloys were prepared at the Hecla Iron Works by Hadfield, and in every case a careful chemical analysis is given in the tables. The paper is divided into four parts. I. *Electric conductivity.*—This was taken for all the alloys. The highest electric resistivity of any known metallic wires is in some of these alloys. Thus, 70 per cent. iron, 25 per cent. nickel, 5 per cent. manganese has resistivity 97·5 microhms (copper in 1·626). The following notes summarise such results as are new :—(*a*) The conductivity of iron is always reduced by alloying, even when the alloying element itself conducts better than iron ; (*b*) the greatest reduction of conductivity is always produced by the first increment of the element added ; (*c*) increase in resistivity according to the element used, follows the same order as increase in specific heat of the elements ; (*d*) annealing always diminishes the resistivity ; in one case quoted the diminution was 14 per cent. II. *Magnetic properties.*—Using a magneto-metric method, B.-H. cycles were taken for most of the alloys. The tables show at a glance the effect on the permeability of increasing the percentage of the elements. The effects of annealing are in some cases remarkable. Thus, a specimen 88 per cent. iron, 9 per cent. chromium, 3 per cent. manganese, gives (1) when unannealed, induction 500, (2) when annealed, induction 13,000, for the same field. III. *Non-magnetic alloys.*—By trial, various alloys have been made having susceptibility in some cases 0, in others only $\frac{1}{1000}$th of that of iron. Yet the proportion of iron in no case is less than 70 per cent. In some cases annealing causes the susceptibility to be increased five times or more. IV. *Alloys more magnetic than the purest commercial iron.*—There are two alloys—(1) 2¼ per cent. aluminium, the rest iron. This is nearly twice as permeable as pure iron for small fields (up to 2 c.g.s.). Its permeability remains greater up to the highest field tried (64 c.g.s.), though the ratio of the two permeabilities decreases steadily as H rises. (2) 2½ per cent. silicon, the rest iron. This is less permeable than the aluminium alloy, though much more so than iron for small fields. But for values of H more than 8 c.g.s. its permeability is surpassed by that of iron. In the discussion on the above paper remarks were made by **Kelvin, R. T. Glazebrook, W. M. Mordey,** and others with reference to hysteresis, "ageing" of iron, and various other practical applications of this research. [See also Abstract No. 1679 (1900)]. P. E. S.

1722. *Magnetic Observations in China during the Solar Eclipse*, Nov. 11, 1901 **J. de Moidrey.** (Terrestrial Magnetism, 7. pp. 23–25, March, 1902.)—Th eclipse was partial at Zi-ka-Wei in China. The observations, not throughou by the same observers, continued for ten hours, commencing about noon, tw hours before the eclipse, and ending one and a half hours after it. Th magnetic elements were not affected by the eclipse. H. E

1723. *Determination of the Value of the Earth's Magnetic Field in Inter national Units, and Comparison with the Values given by the Kew Magnetometers* **W. Watson.** (Roy. Soc., Phil. Trans. 198. pp. 431–462, May 2, 1902 Roy. Soc., Proc. 69. p. 1, Nov. 8, 1901. (Abstract).)—The author undertoo these measurements in view of the discrepancies found to exist between th values of H as measured in the various British observatories. The metho adopted was to compare H with the field produced by a known current in coil of known dimensions. The Helmholtz arrangement was adopted of tw parallel coils at a distance from each other equal to the radius of either. Th coils were mounted on a horizontal circle so that they could be turned abou a vertical axis till the magnetic axis of the needle at the centre of the coil was at right angles to the axis of the coils when the current was passing Then $H = CF/\sin\theta$, where C is the current through the coils, F the field a their centre due to it, and θ the angle through which they are turned. Th current was measured by a silver voltameter, and also by a standar cadmium cell and standard resistance. The construction of the coils an magnetic system, and the precautions taken in measuring them, are full described in the paper. The coil constants were checked by employin different methods of measurement, and F was determined with an accurac of within one part in 6,000. The current employed was 0·05 ampere, an was not measured directly by the silver voltameter, but by a standar cadmium cell and two standard manganin resistance coils in series. Th galvanometer and adjustable resistance used enabled the current to be kep constant to within one part in 120,000. In comparing the standard cell with the silver voltameter, the two resistance coils were placed in paralle and a current of 0·2 amperes used. Both Clark and cadmium cells wer prepared. The former showed differences amounting to four parts in 10,000 even after standing in an ice bath for two weeks, while the latter agree to within one part in 15,000. The cadmium cells were therefore alon employed. The various determinations made of the electro-chemic equivalent of silver are discussed at length, and the author favours Kahle measurements, taking the most probable equivalent to be 0·0011183 for deposit from a fresh solution on a platinum surface. In making measure ments two forms of voltameter were connected in series, Rayleigh's form an the form with a porous pot recommended by Richards, Collins, and Heimro The latter gives values of the equivalent 0·082 per cent. lower, and the autho finds the results obtained from it slightly more concordant than those fro Rayleigh's form, but does not credit it with much advantage. A full table o the results is given, from which it appears that, taking the electro-chemica equivalent of silver as 0·0011180, the value of H determined by the Ke instruments is 0·000007 c.g.s. units lower than that determined by th author's apparatus in international units. To compare the results with th determinations made of the e.m.f. of standard cells, a new set of cadmiu cells was prepared, with an amalgam containing 12·7 per cent. of cadmiu instead of 14 per cent. as in the old cells. The two sets of cadmium cel and the Clark cells were compared, and gave the following results as th

e.m.f. of the old cadmium cells at 20 deg. in international volts, and taking the equivalent of silver to be 0·0011180.

From silver depositions	1·01909
From Kahle's value for cadmium cells ...	1·01855
From the Clark cells	1·01898
Mean	1 01888

Taking this mean value, which uses all the available data, the value of H given by the Kew instruments is 0·00002 c.g.s. units higher than the value in international units, and taking the electro-chemical equivalent of silver to be 0·0011183, and deriving the values from the silver depositions only, the value of H is 0·00004 c.g.s. units higher. G. H. B.

1724. *Magnetic Observations in North America during the Total Solar Eclipse*, May 17–18, 1901. **L. A. Bauer.** (Terrestrial Magnetism, 7. pp. 16–22, March, 1902.)—Reproduction of the special instructions sent to the observers of the U.S. Coast and Geodetic Survey at seven stations, from Sitka in Alaska down to Vieques on Porto Rico, comprising also the two magnetic observatories at Baldwin in Kansas and at Cheltenham in Maryland, and further to the five volunteer stations, including Toronto and El Contadero in Mexico. The entire interval of nine hours fell during night-time, but it was insisted that there should be no change of observers, and further that everything should be in thorough working order two days before the eclipse. At Cheltenham the Eschenhagen magnetograph proved superior to the old Adie form, and the D eye readings, made with the ordinary field magnetometers, as good as the best magnetograph work. The results obtained will be included in the general *résumé* of the international observations. H. B.

1725. *Experiments on Earth Currents.* **E. Jahr.** (Elektrotechn. Zeitschr. 23. pp. 195–197, March 6, 1902.)—Pairs of electrodes of the same or different materials, various metals and carbon or coke, or iron pipes, are buried in the ground or water near Berlin and connected by an insulated copper wire resting on china insulators above ground ; the connecting wire, up to 1 km. in length, lies in the magnetic meridian. Weak currents are observed, the best results being obtained when the northern electrode is sunk to a lower level than the southern (magnetic inclination angle) ; the potential difference and current intensity are stated to be constant when this arrangement is adopted. With multiple earth batteries currents of 2 volts and 2·5 amperes have been observed. The experiments have extended over two years. H. B.

ELECTRO-PHYSIOLOGY AND ELECTRO-THERAPEUTICS.

1726. *Electric Shocks.* **F. B. Aspinall.** (Inst. Elect. Engin., Journ. 31. pp. 748–761 ; Discussion, pp. 773–774 and 777–822, April, 1902. [See Abstract No. 1728 (1902)].)—The author commences his paper with a list of nine questions ; the paper is divided into sections constituting the answers to these questions : (1) Is every one equally susceptible to an electric shock ? The author's opinion is that not only are different people differently affected, but that the same person under different conditions does not feel the same. (2) Is a person suffering from disease more likely to be fatally injured by an electric shock than a person in good health ? The author mentions the case of two persons of weak intellect who could stand abnormally strong shocks,

and one of a man suffering from kidney disease who was so sensitive as to feel the pressure of three Leclanché cells. (3) Does the physiological condition one is in at the time a shock is received make any difference? The case is quoted of a man who received a shock of 2,000 volts between head and buttocks without being killed; he was in a heavy perspiration, which, the author suggests, shunted the current. Another man took 2,000 volts between his hands when drunk, and was not killed. When asleep the shock from a magneto-machine is not felt, and a man received a 5,000-volt shock without being killed. (4) Does the path which the current takes through the body have any effect as regards the shock proving fatal? The author quotes cases tending to show that the path taken is a most important factor. (5) Does the question of contact made, and whether burning takes place or not, have any effect on a person's chance of being killed? The author considers the question of contact most important; with a small or bad contact not only is the resistance greatly increased, but the tendency to burn is increased, and burning seems to afford great protection. Cases are quoted to support this view. (6) Can a person receive a fatal shock without giving the cry, and also can he speak after receiving a fatal shock? The author answers both questions in the affirmative. (7) Is an alternating or a direct-current shock more likely to prove fatal? If contact be made with metal of such a shape that it cannot be gripped and the current passes from hand to hand the direct current seems to knock the victim down, whilst an alternating current seems to draw him closer. On the other hand, if he can grip the metal the direct current holds him tighter. The direct current burns more than the alternating, and the author finds the after-effect of a direct-current shock to be worse. He does not think, though, that one system is more dangerous than the other. (8) Cannot the medical profession give us a more certain method of ascertaining whether a man is dead or not? It is recommended to ascertain if the sphincter muscle is relaxed, but this is objectionable and difficult to judge to a non-medical man. (9) Cannot something more be done to help those who receive a shock? The author suggests that the same treatment should be applied as is used for collapse from chloroform, namely, to hold the body head downwards for a few seconds to flush the brain before applying artificial respiration. G. H. B.

1727. *Electric Shocks at Five Hundred Volts.* **A. P. Trotter.** (Inst. Elect. Engin., Journ. 31. pp. 762–773; Discussion, pp. 773–774 and 777–822, April, 1902. [See Abstract No. 1728 (1902)].)—The paper is divided into three parts: (1) *Physiological and Electrical Conditions.*—The sensation does not depend directly on the actual current but on the current density. With 4 or 5 sq. in. of contact, a current of 1 to 2 milliamperes is hardly perceptible, and one of 10 is painful; with larger currents muscular contractions are caused, especially if the current be unsteady. From boot to boot, where the contact is large, 35 milliamperes is less painful than 14 between the finger-tips where the contact is small. The resistance from boot to boot, the boots being dry and without nails, varies from 45,000 to over 200,000 ohms. (2) *Dangers connected with trolley wires.*—There is no danger in grasping a trolley wire when standing in the street or on a car. With worn boots and after walking 2 miles on wet pavements, the author stood on a rail and grasped a trolley wire; the current was 35 milliamperes and the sensation was endurable for a few seconds; there was no after-effect. (3) *Dangers connected with third rails.*—Even with damp boots there is no unpleasant shock on stepping on a third rail at 500 volts. On touching the rail with the finger, a smart shock i

felt. A serious shock can occur only by making contact with both running and third rails with the bare skin, and by maintaining the contact for some time. G. H. B.

1728. *Electric Shocks. Discussion on Papers by* **C. E. Webber. F. B. Aspinall, and A. P. Trotter.** [See Abstracts Nos. 1730, 1726, and 1727 (1902).] (Inst. Elect. Engin., Journ. 31. pp. 773-774 and 777-822, April, 1902.)—**A. P. Trotter** tabulated the results of his tests of the sensations felt and the currents taken by different members of the Institution at pressures of 100 and 500 volts. **W. S. Hedley** did not agree with Webber's views of the physiological action of the current. He considers the effect to be fibrillar contraction of the heart; when the heart is exposed, a much weaker current applied to it will kill than when the current is passed through the skin. The path of the current is of great consequence. High-pressure currents may kill in a different way by preventing respiration. Where syncope is produced, he favours Aspinall's suggestion that lowering the head may be beneficial. **T. M. Legge** remarks that post-mortem examinations invariably show symptoms of asphyxia, and considers it important to decide whether death is due (1) to failure of respiration followed by failure of the heart; (2) to failure of the heart followed by failure of respiration; (3) to direct action of the current on the heart; or (4) to contraction of the arteries and capillaries. He refers to Prévost and Baccelli's experiments, and agrees with them that with high-pressure alternating currents on dogs, arrest of respiration is the first thing, but that with low tension of 170 volts or less, there is no effect on respiration, but the heart is thrown into a condition of fibrillary contraction for which artificial respiration is useless. **L. Jones**, in discussing Aspinall's paper, agrees with him that the effect of a shock depends very largely on the health and on the physiological condition of the victim. He is not able to give a certain method of ascertaining whether a man is dead or not. He agrees that inverting the victim and blows over the heart may be of use, and advocates rhythmic traction on the tongue to accompany artificial respiration. **M. B. Field** does not quite agree with Trotter that a trolley wire is not a source of danger. With one hand grasping an earthed handrail, the trolley wire may be flicked without danger, but if grasped it may be impossible to let go, and therein lies the danger. A momentary shock may not be dangerous, but a prolonged one of equal intensity may be fatal. The author then refers to the danger that may arise on high-pressure alternating systems from capacity currents. For the treatment of those rendered unconscious from shock he recommends the hypodermic injection of ether or brandy, to stimulate the action of the heart. **L. W. de Grave** gives a table of the sequence of sensations felt on taking shocks at different pressures for twenty minutes. G. H. B.

REFERENCES.

1729. *The Electron Theory of Metals.* **P. Drude.** (Ann. d. Physik, 7. 3. pp. 687-692, March, 1902.)—The author here makes corrections rendered necessary by an error in the sign of the Thomson effect in previous papers. [See Abstracts Nos. 1276 (1900) and 840 (1901).] A. D.

1730. *Electric Shocks.* **C. E. Webber.** (Inst. Elect. Engin., Journ. 31. pp. 732-747; Discussion, pp, 773-774 and 777-822, April, 1902.) [See Abstract No. 1728, (1900).]—The author deals first with the physiological effect of shock, and describes the results obtained by numerous experimenters. He next gives a *résumé* of the legislation for minimising the danger of shock to employés. G. H. B.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1731. *Action of Hydrogen Dioxide on Potassium Metavanadate.* **L. Pissarjewsky.** (Zeitschr. Phys. Chem. 40. pp. 368–371, March 29, 1902.)—Data are given for the heat of solution of KVO_3 and KVO_4 in water, and for the heat evolved by different molecular proportions of hydrogen dioxide when acting on KVO_3. It is found in the last case that the heat of reaction reaches a maximum when we have added two molecular proportions of H_2O_2, to one of KVO_3 and that further addition of hydrogen dioxide does not alter the heat-evolution. From this we may conclude that in addition to the compound KVO_4, obtained by the action of *one* molecule of the oxidising agent, there is formed a further well-defined compound by the action of *two* molecules. D. H. J.

1732. *Action of Hydrogen on Sulphides and Selenides.* **H. Pélabon.** (Annal. Chim. Phys. 25. pp. 365–432, March, 1902.)—The paper deals exhaustively with the equilibria obtained by the action of hydrogen on the sulphides and selenides of silver, mercury, arsenic, antimony, and bismuth, and by the action of sulphuretted or seleniuretted hydrogen on the corresponding metals. The method of experiment consists in heating the constituents in a sealed tube at the desired temperature until equilibrium is attained, and then determining the composition of the gaseous phase by rapidly cooling the system to a temperature at which the speed of reaction is negligible. The results obtained are found to agree with the thermodynamical equations of equilibrium, but the author appears to be ignorant of the phase-rule. F. G. D.

1733. *Chemical Dynamics of Nickel Carbonyl.* **A. Mittasch.** (Zeitschr. Phys. Chem. 40. pp. 1–83, March 18, 1902.)—The following is a summary of the results obtained. (1) Equilibria between nickel, carbon monoxide, and nickel carbonyl can be obtained from either side. (2) Increase of pressure favours the formation of the carbonyl. The dependence of the equilibrium on pressure obeys the theoretical equation, $K = \frac{C'_{CO}}{C_{NiCO_4}}$. (3) The equilibrium varies with the particular form of nickel—strip, amalgam, or powder—employed. (4) The equilibrium varies with the temperature, and in accordance with the positive heat of formation, dissociation of the carbonyl increases with rise of temperature. (5) The decomposition of the carbonyl is a reaction of the 1st order; its formation, constant nickel surface supposed, a reaction of the 2nd order. F. G. D.

1734. *Composition of Gas Hydrates.* **de Forcrand.** (Comptes Rendus, 134. pp. 835–838, April 14, 1902.)—The formula, $\frac{Q}{T'} = 30$, recently shown by the author to hold for the dissociation of gas hydrates, can be applied for the purpose of determining the composition of these substances. Q = heat of formation of solid hydrate from gas and *ice*, T' = temperature (absolute) for which the dissociation pressure of the hydrate equals 760 mm. If Q' = heat of formation of hydrate from gas and *water*, then $Q' = Q + n \times 1430$, if there

are n molecules of water for one of gas in the hydrate. Q′ can be measured directly or calculated by Clapeyron's formula from the dissociation curve, and Q is obtained from the equation $Q = 30T'$, where T′ can be measured directly. Hence n can be calculated. If T′ cannot be conveniently measured, it may be calculated by an application of Clapeyron's formula, provided Q′ is known. The author also gives an alternative method of calculation, and promises applications of the method in a future paper. [See also Abstract No. 854 (1902).] F. G. D.

1735. *Action of Hydrogen on Strontium Amalgam.* **Guntz.** (Comptes Rendus, 134. pp. 838-840, April 14, 1902.)—When strontium amalgam is treated in presence of hydrogen, absorption of the latter begins at about 500°, and a state of dissociation equilibrium is produced, the gaseous system containing the vapours of mercury and strontium as well as hydrogen. But as the extremity of the tube is cooled, mercury is here condensed, and the reaction goes on to completion, *i.e.*, to complete replacement of mercury by hydrogen. Strontium hydride dissociates on heating, and the author has measured the dissociation pressures at 1,000° (100 mm.) and at 1,100 (300 mm.) and thence calculated the heat of formation to be 38·4 Cal. A thermochemical determination of this by the action of water on the hydride gave 34·7 Cal. Finally it is shown how a knowledge of the dissociation pressures enables the conditions for the preparation of metallic strontium from the hydride to be accurately given. F. G. D.

1736. *Initial Action of Iodine in Hydrolysis.* **F. E. Hale.** (Zeitschr. Anorg. Chem. 31. 1. pp. 100–127, 1902.)—It has often been stated that on using amidon as an indicator with ideometric methods—in addition to the well-known blue colouring—a red colour will also frequently appear. The author has tested the causes of the iodine losses attending this phenomenon, and this paper not only shows how to avoid these losses, but affords a probable explanation of the appearance of the red colour, of the causes of iodine losses, and of the mutual connection of both phenomena. It is stated that neither of these phenomena will appear with an absolutely pure and recently prepared amidon solution. Common amidon, as a rule, contains two impurities, one of which will assume a red colour on reacting with iodine, the other turning blue; this latter is readily transformed into the former by the action of oxygen and bicarbonate. These impurities are formed also in pure amidon, both in the dry state and in solution. The latter one is found to be identical with, or analogous to, amiduline (soluble amidon), a compound formed by the action of saliva on pure amidon, the red colouring impurity, erythrodextrine, being the second product of the same reaction. Iodine losses are due to the formation of erythrodextrine from the body analogous to amiduline, whereas with the transformation of erythrodextrine into achrodextrine no iodine is consumed. A. G.

1737. *Solubility of Analogous Salts.* **W. O. Rabe.** (Zeitschr. Anorg. Chem. 31. 1. pp. 154–158, 1902.)—It has been shown by C. Rossi's investigations that the ratio between the molecular weights of analogous salts of such metals as are of a very similar chemical nature, and which belong to the same group of the periodic system, will be a multiple (represented by simple numbers) of the ratio of the corresponding coefficients of solubility. The author, extending Rossi's experiments on metals which, though they show numerous analogies among one another, do not belong to the same group,

and testing the influence of temperature, fails to note any definite relations between the solubilities of different analogous salts of lithium, sodium, silver, and ammonium, and the corresponding thallo-salts, whereas a simple relation is shown to exist in the case of potassium and thallium. It is suggested that with increase of temperature the salt solutions above mentioned may tend towards an equimolecular state, *i.e.*, the state of greatest analogy. Finally, instances are given of a possible bearing of the acid radical on the phenomena in question. A. G.

1738. *Halogen Salts.* **P. Pfeiffer.** (Zeitschr. Anorg. Chem. 31. 2. pp. 191–235, 1902.)—Some years ago Werner published a systematic discussion of the chloro-salts, with a view to show that all the compounds so far known will behave according to the laws of his system. The author endeavours to prove that the same is true of the bromo- and iodo-salts. It results, in fact, from a very full investigation carried out by him that these salts are perfectly analogous to the chloro-salts, and fill up many gaps existing in their system; on the other hand, a most intimate analogy is found to exist between them and the oxy-salts, so that the author suggests regarding all these bodies as members of one great class of compounds with analogous formulæ of constitution. Finally, a systematic survey of the most important double salts of bromine and iodine is given, and a bibliographical table is annexed. A. G.

1739. *Double Salts of Iodine-trichloride with Chlorides of Bivalent Metals.* **R. F. Weinland** and **Fr. Schlegelmilch.** (Zeitschr. Anorg. Chem. 30. 2. pp. 134–143, March 7, 1902.)—Double salts of iodine-trichloride with metallic chlorides have so far been known in the case of the metals of the alkalis, ammonium and magnesium. The authors enter upon the problem, whether, in addition to those mentioned, other chlorides are capable of combining with iodine-trichloride, it resulting from the experiments made that this is true of the chlorides of zinc, nickel, cobalt and manganese, while attempts to obtain similar compounds with chlorides of trivalent metals failed. The composition of these double salts is found to be represented by the following molecular formula, identical with the formula given by Filhol for the magnesium salt:

$$2ICl_3 . R''Cl_2 . 8H_2O.$$

These salts are prepared by adding iodine (more by one-half than the theoretical value) to the aqueous solution of the corresponding chloride, and allowing chlorine to enter until all the iodine has dissolved. The double salt will separate on cooling, the chlorine current being kept on. The authors finally give a very full description of each of the salts obtained. A. G.

1740. *Polyhalogen Compounds of Metals of Alkaline Earths.* **J. Meyer.** (Zeitschr. Anorg. Chem. 30. 2. pp. 113–122, March 7, 1902.)—It has been known for some time that iodine will dissolve readily in solutions of its metallic compounds. Wells and Wheeler having shown that the metals of the alkalis are capable of forming definite polyhalogen compounds, the author has investigated the solubility of iodine in 10 per cent. solutions of the haloids of metals of the alkaline earths, the outcome being that this solubility exceeds by far the solubility in pure water. In order next to ascertain whether halogens in such solutions are chemically bound or physically dissolved, the author uses the cryoscopic method, availing himself of an apparatus to be described in

a subsequent paper. The main result of these experiments is that the freezing-points of such solutions will be but little altered by the addition of halogens, even the sign of that alteration being variable. Hence the author draws the conclusion that in such solutions there may exist polyhalogen compounds largely dissociated. Endeavours to prepare these bodies in the solid state succeeded only in the case of iodides of metals the alkaline earths. These solid polyiodides the author regards as molecular compounds; while with polyhalogen compounds of the metals of the alkalis, the stability will increase towards cæsium; metals of the alkaline earths will show an opposite behaviour, the calcium compound CaI_4 being the most stable. [See preceding Abstract.] A. G.

1741. *Heat of Reaction between Bodies in the Solid and Gaseous States.* **Ponsot.** (Comptes Rendus, 134. pp. 651–653, March 17, 1902.)—If two bodies A and B produce others, M and N, by chemical reaction, we may consider at the same temperature T, and under the same volume V, two systems, one containing A and B, the other M and N, in each the solid bodies being accompanied by a mixture of their vapours. Supposing in the mixture of vapours, in presence of the solid bodies, a chemical modification at temperature T_1 to increase by dm the second system at the expense of the first, without being accompanied by vaporisation and condensation due to the presence of the solids, it follows that $dU/dm_v = T_1 . ds/dm_v + dt/dm$, where t is the thermodynamic potential; from considering the same modification to occur in the solids it follows that $dU/dm_s = T_1 . dS/dm_s + dt/dm$, and that therefore dU/dm_s and dU/dm_v tend towards the same value as T_1 approaches absolute zero. It is shown further that the heat evolved in the total reaction of the bodies taken in the solid state and under a pressure produced by the pressure of the vapours they emit, and the heat evolved in the total reaction under constant volume of the same bodies in the gaseous state tend towards the same value at absolute zero. [See also Abstract No. 1962 (1901).] W. E. T.

1742. *Mechanism of the Catalytic Action of Iodine on Bromination.* **L. Bruner.** (Acad. Sci. Cracovie, Bull. 3. pp. 181–200, March, 1902.)—In the bromination of benzene in the presence of iodine the author finds that the reaction is of the 2nd order, so far as the calculation of a constant is concerned, but that if examined by the varying concentration method it is really quadrimolecular. This is explained by the equation—

$$C_6H_6 + 4Br = C_6H_5Br + HBr_3.$$

On determining the bromine which has disappeared by titration with potassium iodide and thiosulphate, the four bromine atoms only count as two, since the HBr_3 breaks up into $HBr + Br_2$.

The catalytic action of the iodine is ascribed to the formation of IBr and its dissociation into atoms. When the bromine left in the solution falls to an amount corresponding to the formation of IBr, the reaction falls off greatly in speed. This is ascribed to a decreased dissociation of the IBr, resulting from an increase in the concentration of the iodine atoms with which there is now no excess of bromine atoms to combine. F. G. D.

1743. *Catalysis and its Applications.* **J. T. Conroy.** (Soc. Chem. Ind., Journ. 21. pp. 302–312, March 15, 1902.)—The author refers to Ostwald's

address on this subject before the Deutscher Naturforscherversammlung in Hamburg, in September, 1901, and quotes with approval Ostwald's remark that—"there appears to be no kind of chemical reaction which cannot be influenced catalytically, and no form of chemical substance, be it elemental or compound, which cannot act as a catalyst." The author then proceeds to discuss practical examples of catalytic action, the instances selected being chiefly of industrial significance. This portion of the paper is very full and complete, and the classification adopted can only be given in this Abstract. INORGANIC PROCESSES.—*Chlorine and Chlorine Products:* The Deacon chlorine process, the Imhoff chlorate process. *Sulphur:* The Claus kiln action for oxidation of SH_2. *Sulphuric Acid:* All contact processes. ORGANIC PROCESSES.—*Aldehydes:* Trillet's and other processes. *Acetic Acid and Acetone:* Behren's and Squibb's processes. *Carbon tetrachloride:* Lever and Scott's process. The author concludes by drawing attention to the theory of catalytic action, based on intermediate chemical reactions. The importance of the work now being carried on in this field of chemical inquiry is referred to, and its significance for the chemical manufacturer is emphasised. J. B. C. K.

1744. *Solubility of Ammonia in Salt Solutions.* **R. Abegg** and **H. Riesenfeld.** (Zeitschr. Phys. Chem. 40. pp. 84–108, March 18, 1902.)—The partial pressure of ammonia when dissolved in water or in salt solutions obeys Henry's law very closely between the concentrations $\frac{N}{2}$ and N of the ammonia, and in the case of salt solutions the change of pressure is approximately proportional to the concentration of the salt. The alkaline hydroxides, fluorides, borates (KBO_2 &c.), acetates, formates, chlorates, bromates, and iodates, and the salts of all the polyvalent acids greatly increase the partial-pressure of the ammonia, and thus reduce the solubility of the ammonia in the water. The effects are approximately additive, the order of magnitude for the kathions being K, Na, Li, NH_4, and for the anions being OH, F, ClO_3, BrO_3, IO_3, NO_3, Cl, Br, I, &c. In a few exceptional cases, such as $MgCl_2$, $CaCl_2$, $SrCl_2$, $BaCl_2$, LiCl, LiBr, LiI, an opposite effect is produced, the solubility being increased by the presence of the salt; this result is perhaps due to the combination of ammonia with the salts. In the majority of cases the lowering of solubility of ammonia runs parallel with the lowering of solubility of other volatile substances, such as hydrogen, nitrous oxide, carbon dioxide, ethyl acetate, and phenylthiocarbamide; this is true for Na_2SO_4, Na_2CO_3, and the nitrates of the alkali-metals, but in other cases such as $MgSO_4$, $CaCl_2$, and the chlorides of the alkali-metals ammonia behave abnormally, and probably interacts with the dissolved salt, a conclusion that has already been arrived at from the study of the ammonia results by themselves. [See also Abstract No. 1699 (1900).] T. M. L.

1745. *van der Waals' ψ-surface.* **W. H. Keesom.** (Konink. Akad. Wetensch. Amsterdam, Versl. 10. pp. 782–793, March 29, 1902.)—In this paper the author applies the relation for the ratio of the compositions of coexisting phases in the presence of small amounts of an impurity to the case of mixtures, by means of the law of corresponding states. This relation is next tested by Hartman's observations with regard to the composition of coexisting phases in mixtures of methyl chloride and carbonic acid. The author subsequently goes on to deduce formulæ for the difference of the

saturation pressures of the mixture and the pure substance respectively, and the increase in pressure by condensation of the mixture. These formulæ afford a means of ascertaining the amount of impurity from the increase in pressure observed, the saturated vapour tension of the pure substance being next found from the initial and final condensation pressures of the impure substance. The last formula is finally tested on Kuenen's observations regarding impure ethane, satisfactory accordance being claimed. A. G.

1746. *Microscopical Examination of the Alloys of Copper and Tin.* **W. Campbell.** (Inst. Mech. Engin., Proc. 5. pp. 1211–1250; Discussion, pp. 1251–1272, Oct.–Dec., 1901. Appendix to Reports of Alloys Research Committee.)—The author has studied the microscopical structure of the copper-tin alloys when suddenly quenched at different temperatures in order to stereotype the structure then existing in them. Over 100 photo-micrographs are given of specimens prepared in this way. The results are substantially in agreement with those that have been obtained independently by Heycock and Neville whose diagram [see Abstract No. 1382 (1902)] is reproduced in the discussion on the paper. T. M. L.

1747. *Transformations of Steel by the Dilatometric Method.* **G. Charpy** and **L. Grenet.** (Comptes Rendus, 134. pp. 598–601, March 10, 1902.)—The study of the transformations of steel by the dilatometric method has the advantage that the changes of temperature can be made to proceed at any rate, and transformations can easily be studied at stationary temperatures. The best results are obtained by heating the sample at the rate of about 200° C. per hour; the lag of the transformations is then inappreciable. In all cases a carbon-iron alloy, when heated, exhibits an abrupt contraction in the neighbourhood of the critical point a, of the pyrometric measurements, *i.e.*, at about 700° C.; the magnitude of the contraction reaches a maximum at about 0·85 per cent. C. Above this temperature expansion recommences, but with a much smaller coefficient than below the critical temperature; the coefficient then gradually decreases, becomes negative, and again positive. The second contraction is not abrupt like the first, but extends over a range of temperature, and is only noticeable in steels containing less than 0·65 per cent. C. The first contraction is probably due to the resolution of the eutectic alloy (pearlite) of iron (ferrite) and carbide (cementite, Fe_3C.). At higher temperatures the gradual absorption of the excess of ferrite causes a contraction in the case of alloys containing less than the eutectic proportion of carbon, whilst the gradual absorption of the excess of cementite causes an expansion in alloys containing more than the eutectic proportion of carbon. T. M. L.

1748. *Oceanic Salt Deposits. Formation of Langbeinite [and its lower temperature limit in salt-beds at 37°].* **J. H. van't Hoff, W. Meyerhoffer,** and **F. G. Cottrell.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 15. pp. 276–282, March 6, 1902.)—Langbeinite, $K_2Mg_2(SO_4)_3$, is found in the Stassfurt salt-beds, but cannot be produced at 25°. Schönite, $K_2Mg(SO_4)_2$, $6H_2O$, is converted into leonite, $K_2Mg(SO_4)_2$, $4H_2O$ at 47·5°, or 41°, according as K_2SO_4, or $MgSO_4$, is present in excess; further dehydration occurs at 72·5°, but the product is not langbeinite, but a complex of the formula $K_2Mg_4(SO_4)_5$, $5H_2O$. The conversion of leonite into langbeinite, according to the equation $2K_2Mg(SO_4)_2$, $4H_2O = K_2Mg_2(SO_4)_3 + K_2SO_4 + 8H_2O$ takes place on heating in a sealed tube; the transition-temperature was found with some difficulty to be about 83°. The formation of langbeinite from leonite and magnesium sulphate

$K_2Mg(SO_4)_2$, $4H_2O + MgSO_4$, $6H_2O = K_2Mg(SO_4)_3 + 10H_2O$ takes place above 61°; if the separation of langbeinite is delayed, the unstable compound $K_2Mg_3(SO_4)_3$, $5H_2O$ is liable to separate, but disappears again when langbeinite has begun to crystallise. A solution saturated with K_2SO_4 and $MgSO_4$ contains at 88·5° $1000H_2O$, $4MgSO_4$, $27K_2SO_4$, and at 61·5° $1000H_2O$, $83MgSO_4$, $7K_2SO_4$; from such a solution saturated at 85°, or above, langbeinite can be obtained, but a better method of preparation is to add magnesium chloride as a dehydrating agent, and subsequently to extract it with alcohol. The formation of langbeinite from leonite, which is lowered from 89° to 61° by the presence of magnesium sulphate, takes place at 37° in a solution saturated with salt, and this is probably the lowest temperature at which it can have been deposited in the Stassfurt beds. [See also Abstracts Nos. 512 and 735 (1902).] T. M. L.

1749. *Condensation of Vapours of Organic Liquids in Presence of Dust-Free Air.* **F. G. Donnan.** (Phil. Mag. 3. pp. 305–310, March, 1902.)—When expanded adiabatically, water condenses as a fine rain round a few nuclei for expansions above 1·25, but as a fog round a large number of nuclei for expansions above 1·38. It was thought that this behaviour might be general in "ionising solvents," but that condensation would occur less readily in the vapour of non-ionising solvents. It was found that methyl and ethyl alcohol behaved somewhat like water, but that condensation occurred less readily in the case of carbon tetrachloride, benzene, and chlorobenzene; carbon disulphide, however, though a non-ionising solvent, was found to condense with remarkable readiness. The results are shown in the table:—

	Rain-point expansion.		Dew-point expansion.
Water	1·29	...	1·42
Methyl alcohol	1·32	...	1·42
Ethyl alcohol	1·20	...	1·25
Carbon tetrachloride	1·89	...	Not observed
Carbon disulphide	1·05	...	1·08
Chlorobenzene	1·48	...	1·60
Benzene	1·53	...	1·78

[See also Abstract No. 1025 (1900).] T. M. L.

1750. *Chromium Hydroxide.* **W. Fischer** and **W. Herz.** (Zeitschr. Anorg. Chem. 31. 3. pp. 352–359, 1902.)—It has been known for some time, from W. Herz's and Hantzsch and Rubenbauer's researches, that numerous inorganic compounds will first be produced in a soluble modification, and, by degrees, pass into a more insoluble form. In this paper it is stated that chromium hydroxide, immediately on being prepared, will be capable of readily dissolving in bases. This property, however, is lost slowly on being left undisturbed, more rapidly on being heated, or filtered and dried. A. G.

1751. *Validity of the Ionisation Theory.* **H. M. Dawson.** (Nature, 65. pp. 414–415. March 6, 1902.)—The author criticises a paper on this subject by L. Kahlenberg, in which molecular weights were calculated from experimental results on solutions which were not dilute. [See Abstract No. 2203 (1901).] Since the ordinary freezing-point and boiling-point formulæ rest on a thermodynamical basis, they only hold good for ideal solutions, and it is not justifiable to apply them to strong solutions. For solutions of this kind, Ewan, amongst others, has deduced a formula, which, when applied to sugar

solutions, gives values scarcely differing from theory, even up to a concentration of 40 per cent. Since the ordinary formulæ cannot be applied, results derived from them cannot be compared with those due to conductivity measurements; besides which the ranges of concentrations employed by Kahlenberg are quite different. It is also doubtful if the formula $\alpha = \mu_v/\mu_\infty$ really gives degrees of ionisation, for it involves the unproved and scarcely probable assumption that ionic velocities are the same for all concentrations. In attacking the theory it is necessary to consider very carefully what is stipulated in the basis. W. R. C.

1752. *Cuprous and Cupric Ions.* **G. Bodländer** and **O. Storbeck.** (Zeitschr. Anorg. Chem. 31. 1. pp. 1–42, 1902.)—The experiments recorded in this paper lead to the following conclusions: Cuprous chloride, on being exposed to the action of water, is decomposed into cuprous hydroxide and free hydrochloric acid on one hand, and on the other into cupric chloride and metallic copper, the latter process being the prevailing one, and capable of being restrained by the addition of increasing amounts of chlorides, so that cuprous chloride will dissolve without decomposition in solutions more than 0·05 normal with regard to potassium chloride. In aqueous solutions cuprous chloride is present partly ionised. A method, based on measurements of concentration cells, of ascertaining the formula of complex salts in solution has been tested. Solutions 0·05 — 0·4 normal of potassium chloride will dissolve cuprous chloride with formation of the compound $KCuCl_2$, while in more concentrated chloride solutions the formula of the complex salt will be K_2CuCl_3. Since the molecules of the complex cupro-salts contain no more than one atom of copper, these experiments do not afford sufficient evidence as to the mono- or bi-valency of the free ions. [See also Abstract No. 175 (1901).] A. G.

1753. *Relative Velocities of the Ions in Solutions of Silver Nitrate in Pyridine and Acetonitrile.* **H. Schlundt.** (Journ. Phys. Chem. 6. pp. 159–171, March, 1902.)—The author has determined the migration velocities of the silver ion in solutions of pyridine and acetonitrile. The apparatus employed in most of the experiments was that devised by Nernst and Loeb; in two experiments Bein's apparatus was used. The following tables give the temperatures, the concentrations of the silver nitrate solutions employed, and the transference numbers for the kation, as determined from the change of concentration at the anode and kathode respectively.

	Solvent: Pyridine.										Solvent: Acetonitrile.			
	23°	18·5°	23°	0°	19°	21°	0°	22°	22°	...	18°	19°	17°	19°
Approximate concentration	n	$\frac{1}{2}$-n	$\frac{1}{2}$-n	$\frac{1}{2}$-n	$\frac{1}{10}$-n	$\frac{1}{10}$-n	$\frac{1}{10}$-n	$\frac{1}{40}$-n	$\frac{1}{40}$-n	...	n	$\frac{1}{40}$-n	$\frac{1}{11}$-n	$\frac{1}{32}$-n
N at anode	32·6	34·1	34·3	33·5	40·4	38·7	40·2	43·2	44·7	...	38·5	42·4	45·2	46·9
N at kathode	32·7	—	34·0	33·6	—	38·7	40·6	43·9	44·5	...	38·2	42·0	44·5	47·3

Comparison shows that the transference number of Ag. varies considerably with the solvent, but there is an apparent convergence to the same value, 47. In the case of aqueous solutions of certain salts which show a marked affinity for the solvent, the transference number increases with increasing dilution; this is also the case with Ag in pyridine and acetonitrile solution, and this behaviour leads the author to the conclusion that the variations in the ionic velocities are due to a complex union of solvent and dissolved substance, and not to the presence of several kinds of complex free ions of the solute. A. F.

1754. *Hydrogen in the Atmosphere.* **Rayleigh.** (Phil. Mag. 3. pp. 416–422, April, 1902.)—From determinations of the hydrogen in country air by

means of the spectroscope, and by passing dry air over heated copper oxide, and collecting the water formed in a phosphoric oxide tube, the author concludes that the free hydrogen present does not exceed 1/30,000 of the volume, or about 1/7 of that found by Gautier. (Comptes Rendus, 1900, 131. 86.) [See also Abstract No. 886 (1901).] S. R.

1755. *Osmotic Pressure of Solutions Calculated from the E.M.F. of Cells.* **T. Godlewski.** (Acad. Sci. Cracovie, Bull. 3. pp. 146–163, March, 1902.)—If $f(pth)$ is the difference of the thermodynamic potentials $\zeta(pt)$ and $\phi(pth)$ of unit mass of the solvent in the pure state and in the solution, where h is the degree of concentration of the solution, ω its osmotic pressure, the excess of the pressure of the solution p_1 over that of the solvent p_0 when the system is in equilibrium, w the volume of unit mass of the solvent, and μ_s its coefficient of compressibility for pressure p_0, the equation $f(p_1th) = \omega w + \frac{1}{2}\omega^2\mu_s + \frac{1}{6}(\partial\mu_s/\partial p)w^3$ follows from the condition for equilibrium $\phi(p_1th) = \zeta(p_0t)$; the osmotic pressure of a solution of any degree of concentration may then be calculated if the value of f be known. The numerical values of f were obtained for solutions of $ZnCl_2$, $CdCl_2$, $CdSO_4$, of various concentrations from determinations of the e.m.f. of cells of the types Hg—HgCl—$ZnCl_2$—Zn Amalgam, Hg—Hg_2SO_4—$CdSO_4$—Cd (Am), and Hg—HgCl—$CdCl_2$—Cd (Am) by means of graphical integration from the equation—

$$\partial f/\partial h = -n\mathrm{F}/\mu . h\partial \mathrm{E}/\partial h .$$

(Duhem, Potentiel Thermodynamique, 1895, p. 117). The effect of taking account of the compressibility of the water is never found to be greater than 3 per cent., as the terms of the second and third degree, having opposite signs, mutually neutralise one another. W. E. T.

1756. *Gas Cells.* **R. Lorenz.** (Zeitschr. Anorg. Chem. 31. 2. pp. 275–279, 1902.)—After discussing Bose's remark on Czepinski's work [see Abstract No. 1156 (1902), the author distinguishes, according to Nernst's theory, four kinds of potentials occurring in gas cells, the first being the case of an electromotively effective gas passing into its ions at an electrode, as H_2, for instance, may pass into H-ions. The second case is that of an electromotively effective gas being mixed with one electromotively ineffective, the latter being at the same time chemically indifferent as well (with regard to all the substances present). Those potentials are what the author terms "physical dilution potentials." As the diluting gas, though electromotively uneffective, is not chemically indifferent, the case of a "chemical dilution potential" will be realised, the partial pressure of the electromotively operative gas corresponding to the state of equilibrium of the chemical reaction occurring, provided the substance produced be electromotively indifferent as well. The last case considered by the author is the one of several electromotively operative gases being present simultaneously at the gaseous electrode, *e.g.*, in the case of oxy-hydrogen gas being led to an electrode, when potentials oscillating between those of oxygen and hydrogen will be obtained. These potentials the author terms "mixture potentials." A. G.

1757. *Velocity of Electrolysis of Oxalic Acid.* **T. Åkerberg.** (Zeitschr. Anorg. Chem. 31. 2. pp. 161–191, 1902.)—When electrolysing a mixture of oxalic acid and sulphuric acid solution with clean platinum electrodes, the oxalic acid is found to undergo electrolysis only to a nearly insensible degree.

On using platinised anodes, the oxalic acid will be decomposed ; from this fact it is inferred that this reaction is a secondary phenomenon, *i.e.*, that the decomposition of the oxalic acid is due to a purely chemical action of the oxygen evolved by electrolysis. This reaction may follow two different laws, according to concentration. In the case of the amount of oxalic acid being large, the decomposition will practically follow Faraday's law, especially as the current density is small and the temperature high. But after a certain dilution of the solution, electrolysis will occur according to the monomolecular law, $dx/dt = k(a - x)$, the passage between the two laws being fairly abrupt. The transition-point is found to be dependent upon the current density, the monomolecular law beginning later, as the current density is less. This reaction being a monomolecular one, the oxygen cannot act as a molecule O_2, but will act as an atom O. It will hence occur according to the following scheme :—

$$<\begin{matrix}\mathrm{COOH}\\ \mathrm{COOH}\end{matrix} + \mathrm{O} \longrightarrow 2\mathrm{CO_2} + \mathrm{H_2O}.$$

The constant k is found to be independent of the current density, affording further evidence in favour of secondary chemical nature of the reaction. Between 15° and 55° this constant will practically vary as the temperature.

A. G.

1758. *Direct Combination of Chlorine and Carbon.* **W. v. Bolton.** (Zeitschr. Elektrochem. 8. pp. 165–170, March 20, 1902.)—Hitherto no direct combination of carbon with chlorine has been observed. Davy found that an arc between carbon poles in an atmosphere of chlorine brought about no combination. The author has examined the effect of burning an arc light in different gases. If the arc be started in a vacuous receiver, and a little air admitted, first CO_2 and then CO is produced. On admitting more air there is a violent explosion, due to the mixture of CO and O_2. If the receiver be filled with HCl gas, at first there is decomposition into H_2 and Cl_2, followed by recombination with explosion. If acetylene, benzene vapour, or many other gases rich in carbon be used, a thick deposit of soot is rapidly formed, and the arc stopped. On making the arc between carbon poles in an atmosphere of carbon tetrachloride, the latter was split up into carbon and chlorine. When a stream of pure dry chlorine was passed through the apparatus, the carbon electrodes were acted upon, but no product was isolated ; however, on allowing the arc to burn in the receiver, full of chlorine, the author obtained about 0·02 grm. of a white crystalline body, which was deposited on the sides of the vessel, and had the melting-point and properties of hexachlor benzene C_6Cl_6. To obtain this amount of substance, a current of 5·5 amperes and 42 volts was passed for six hours. To improve the yield, the author constructed another form of apparatus, the upper part of which contained the arc in chlorine gas, and the lower a circular vessel, immersed in a cooling mixture to facilitate the separation of the volatile carbon chloride. The amount of oxygen contained in the electrodes was altogether negligible, so that the formation of $COCl_2$ was not possible, except in traces. After passing a current of 6 amperes and 43 volts for a period of six hours, about 0·6 gram of a white crystalline solid was obtained, smelling of camphor, and having a melting-point of 114° C.–186° C. Both quantitative and qualitative analyses led to the formula C_2Cl_6, hexachlorethane. The carbon electrodes were acted on differently, the negative one being pitted with small uniform holes. The author considers it probable that carbon also combines directly with bromine and iodine, as by operating

in a similar manner he was able to obtain crystalline deposits; he has not yet been able to complete his researches in this direction, owing to lack of time. The paper contains diagrams of the apparatus used. W. C. B.

1759. *Artificial Graphite and Platinumiridium as Anode Material.* **F. Foerster.** (Zeitschr. Elektrochem. 8. pp. 143–147, March 6, 1902. From the Elektrochem. Laboratorium der Techn. Hochschule at Dresden.)—The author has carried out experiments with artificial graphite prepared by the Acheson method, with a view to determining its usefulness and efficiency as anode material in the electrolysis of aqueous solutions. Employed as anode in the electrolysis of a neutral, 20 per cent. solution of sodium chloride in the presence of chromate, at a temperature of 60°, with a current density of 0·04 amp./sq. cm., only 7·4 per cent. of the current energy is lost owing to attack of the graphite, and this resistance to chemical attack is maintained even when the current density is 0·12 amp./sq. cm., and the electrolysis continued for 100 hours. When, however, the graphite is used as anode in the electrolysis of sulphuric acid its resistance to chemical attack is no greater than that of amorphous carbon, although the mechanical destruction is not nearly so great, and there is no formation of humus substances. In the electrolysis of solutions of caustic soda at the ordinary temperature Acheson graphite is almost unacted on, and there is no formation of brown, soluble oxidation products, and this holds also even when the temperature is 60–70°, although in this case the graphite is appreciably attacked. Artificial graphite is, therefore, greatly superior to amorphous carbon as anode material in the electrolysis of solutions where the anode potential of the oxygen is comparatively low, but this superiority disappears when the oxygen potential becomes fairly great, as in the electrolysis of dilute sulphuric acid. The author has also studied the use of a platinumiridium alloy, free from ruthenium, and finds that, whether employed as anode or as kathode in the electrolysis of neutral potassium chloride, in presence of chromate, at a temperature of 45°, the electrode remains unimpaired even when the current density is 1,000 amp./sq. m. and after the passage of 2,500 ampere-hours. A. F.

1760. *Formation of Calcium Carbide.* **V. Rothmund.** (Zeitschr. Anorg. Chem. 31. 1. pp. 136–146, 1902.)—Raising the temperature may have two different effects on chemical processes, as the reaction occurring at low temperatures may take place with far greater velocity at high temperatures, and as, on the other hand, rise of temperature will often alter the chemical affinity. A diminution of free energy attending the reaction, the equilibrium is displaced and the direction of the reaction is frequently reversed in the latter case.

As, in the case of carbon, both phenomena may occur, the author tests the conditions of the formation of calcium carbide in the electrical furnace. A carbon tube traversed by the electric current served as furnace, and temperatures were measured by determining the amount of visible radiation given off by this "black" body, as was first suggested by Ed. Becquerel (1864). A mixture of coal and lime was heated to a white heat within this furnace, and, after cooling, the amount of carbide was ascertained by treating the residue with water. From these experiments it is inferred that the formation of calcium carbide is a reversible phenomenon, as, below the transition-point, decomposition of carbide by carbon monoxide into lime and carbon will take place. A. G.

1761. *Theory of the Electrolytic Rectifier.* **K. Norden.** (Elect. World and Engineer, 38. pp. 681–682, Oct. 26, 1901.)—Rectification cannot be due to back e.m.f., for, on stopping a cell, the e.m.f. is found not to exceed 3 volts at the most. Neither can the effect be explained by the high resistance of the film giving rise to a condenser. The author's work has shown that the film consists simply of $Al_2(OH)_6$, which is acted on chemically, passing into solution during half of each period, the plate being oxidised during the other half. W. R. C.

1762. *Electrolytic Conductivity of Liquids.* **G. di Ciommo.** (N. Cimento, 3. pp. 97–121, Feb., 1902.)—The distinction between conducting and non-conducting liquids is only a matter of degree, for all liquids conduct to some extent. The amount of resistance in mixtures cannot be calculated from the simple consideration of the respective percentages ; it is generally less than would have been expected, but the divergences vary with the percentages. Abnormalities are fully discussed; the condition of the liquid becomes profoundly modified upon the mutual solution of two liquids. A. D.

1763. *Electrolytic Reduction of Nitric Acid.* **J. Tafel.** (Zeitschr. Anorg. Chem. 31. 3. pp. 289–326, 1902.)—This is an investigation of the alterations which nitric acid will undergo by electrolysis in the neighbourhood of the kathode, considerable amounts of sulphuric or hydrochloric acid being present. A reduction will occur with most kathodes, excepting, for instance, platinum. The mean products of this process are ammonia and hydroxylamine, their ratio depending on a whole series of factors, and varying to a high degree, according to the nature of the kathode, whereas the sulphuric and hydrochloric acids do not seem to exhibit any marked differences. The largest amounts of hydroxylamine are evolved with pure mercury kathodes, or well amalgamated electrodes, the formation of ammonia being almost wholly prevented in some cases, so as to obtain a nearly perfect quantitative transformation of nitric acid into hydroxylamine salt, whereas, in the case of lead kathodes, the amount of the acid transformed into hydroxylamine was not higher than 40 per cent., for copper 15 per cent. at the most. The rate of this reduction is smallest in the case of copper electrodes. It is next shown that, with electrodes giving rise to this reduction process, hydroxylamine sulphate will equally be reduced, and *vice versâ*. From these facts it is argued that the electrolytic reduction of nitric acid to ammonia at copper kathodes does not pass through hydroxylamine. In order to account for these phenomena, an hypothesis analogous to Chilesotti's interpretation of the effect of different kathodes on the reduction of nitrobenzol is suggested, certain materials, as, for instance, copper, transforming the reduction process leading from nitric acid to hydroxylamine, by a chemical action, from its essentially electrolytic nature, so as to produce ammonia directly. These experiments tend to show the existence of a specifically electrolytic reduction effect with a given kathode and a given electrode, this effect being in some cases not only quantitatively, but qualitatively, different from the corresponding chemical effect. A. G.

REFERENCE.

1764. *Determination of Capillarity-constants.* **M. Cantor.** (Ann. d. Physik, 7. 3. pp. 698–700, March, 1902.)—This is a criticism of Whatmough's method of determining capillarity-constants [see Abstract No. 734 (1902)], containing a description of a modified form of apparatus for the purpose. T. M. L.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

1765. *Oscillating Compound Engine.* (Scientific American, 86. pp. 384–385, May 31, 1902.)—This is a compact semi-rotary engine in which the pistons consist of radial blades, which oscillate between the walls of chambers which form the cylinders. Steam is admitted to these chambers by means of slide valves. The stroke of the blades is 8 in., and they are carried by a shaft on which is keyed a pinion gearing with a sector on a parallel shaft. Motion is transmitted from the sector-shaft to the crank-shaft by means of connecting rods. The crank-throw is 3 in. An engine capable of developing 9 b.h.p. occupies about 1 cub. ft. C. R. D'E.

1766. *Fuel Oil.* **W. W. Reed.** (West. Electn. 30. pp. 302–303; Discussion p. 303, May 3, 1902. Paper read before the South-Western Gas, Electric and Street Rly. Association at San Antonio, Texas, April 19, 1902.)—This paper deals with the advantages inherent to the use of oil fuel as regards cost of handling fuel, steaming capacity, cleanliness, and safety, control of firing, and economy. It is based on the facilities yielded by the oil supply at Beaumont, Texas. Comparisons of the calorific values of oil and coal are taken from Professor Phillips' report on Texas petroleum, in which he gives 17,000 to 20,000 B.Th.U. as the heat value of petroleum, assuming an average of 18,500 B.Th.U. For Alabama coals he gives 13,500 B.Th.U., the same for good McAlester coal; for New Mexico coal 12,000, and for Lignite 9,900 B.Th.U. On this basis one barrel of crude petroleum weighing 320 lbs. net, would be equal to 438 lbs. Alabama or McAlester coal, 492 lbs. New Mexico coal, and 598 lbs. of Lignite. The calculated number of barrels of oil equal to 1 ton of coal would be:—

1 ton	Alabama coal	equal to	4·56	barrels	of oil.
1 „	McAlester coal	„	4·56	„	„
1 „	New Mexico coal	„	4·06	„	„
1 „	Lignite coal	„	3·34	„	„

Results based on practice give from 2½ to 4 barrels of oil to a ton of soft coal. An evaporative test made by the Houston Electric Company with two Babcock-Wilcox boilers gave 13·48 lbs. of water evaporated from and at 212° F. per lb. Texas oil, which weighed 7·43 lbs. per gall. Another test by the Houston Water Company showed an evaporation of 14·71 lbs. water from and at 212° F. per lb. oil. Regarding the relative efficiencies of different forms of burners, four kinds gave the following results:—

No. 1 burner	.....	0·713	gallons per kw.-hour.
No. 2 „	.....	0·667	„ „
No. 3 „	.....	0·606	„ „
No. 4 „	.....	0·575	„ „

The high efficiency of No. 4 was due to the use of highly superheated steam, and a device for intimately mixing it with the oil. The construction of the firebox also greatly influences the result. Although the sulphur in

Beaumont oil has been estimated by analysis at from 1·33 to 2·04 per cent. no bad effects on boiler surfaces have been produced. In the discussion, **F. C. Bitgood** gave the experience of the Hartford Steam Boiler and Insurance Company as to the effects of Beaumont and Corsicana oil on boilers, and corroborated the statements that there were no deleterious effects, but that there was less wear and tear, due to even heating, and consequently less repairs. He, however, warned users as to the danger of raising steam too quickly from cold boilers, and of unduly forcing the boilers, the large supply of flame from the oil exposing them to both of these results unless care were exercised. F. J. R.

1767. *Comparative Boiler Trials in Italy.* (Engineering, 73. pp. 635–637, May 16, 1902.)—This is a preliminary article giving data of the dimensions of the hulls and machinery of the warships *Giuseppe Garibaldi*, and *Varese*, the one having Niclausse boilers, and the other Belleville boilers, comparative trials of which are being carried out by the Italian Government. Unfortunately these ships have not been built to the same lines, nor are the details of engines, boilers, or propellers identical, so that the trials are robbed of much of their value for comparison. The article, however, illustrates and describes the ingenious electrical apparatus invented by L. Perroni for signalling in each of the stokeholds the time at which the fires must be stoked, in accordance with the rate of total combustion per hour determined upon for a given h.p. This apparatus has been found to work admirably, and to tend to economy of fuel, as well as to lessening the labour of the stokers. It, of course, eliminates the irregularity due to chief stokers preferring to govern the stoking by the steam pressure or some other element. It consists of a clock with different series of electrical contacts (according with the different grades of stoking worked out for the engines and boilers) controlled by a switch. These operate electric bells in the stokeholds, and thus give automatic signals in them all simultaneously. F. J. R.

1768. *Alberger Cooling Tower.* (Eng. and Mining Journ. 73. p. 665, May 10, 1902.)—This tower is made in two forms, one for a natural draught of air, due to the air becoming heated by the hot water from the jet condenser, and one for the use of fans for circulating the air. The former has a stack above the cooling-tower proper, and is usually made 80 ft. high above ground level. Illustrations of these forms, with the accompanying condensing and pumping plant, accompany this article. F. J. R.

1769. *The Underfeed Stoker.* (Electrical Times, 21. pp. 947–948, June 19, 1902.)—This is one of the most recent forms of apparatus for supplying coal to furnaces below the bars, so that the green coal is delivered at the underside of the fire instead of being thrown on its surface. The difficulties formerly encountered in efforts to apply this system of feeding fires are in this case dealt with by causing the grate to slope downwards towards both sides from the centre, the feeding-trough being directly under the apex at that point. The grate-bars are made of peculiar section, and are hinged and linked together so as to permit of a modified rocking motion, which tends to spread the fuel. The hopper-trough, with its hollow steel-feeding helix, has a diminishing area towards the rear of the furnace. This causes the fuel to be gradually forced upwards, and the creeping movement of the bars spreads it in a uniform layer over the bars. The hopper outside the furnace has also some useful features, and the dead plates being at the sides, and not at the

back of the furnace, facilities for examination and cleaning are present in this design, which others have lacked. Some tests have shown good evaporative results, figures of which are given. F. J. R.

GAS AND OIL ENGINES.

1770. *Revolutions and Turning Moment of High-speed Petrol Motors.* **R. Conrad.** (Motorwagen, 5. pp. 71–76, March 15, 1902.)—This article describes the results of experiments conducted on the "Protos" motor with the object of showing that in high-speed petrol motors the increase in turning moment is practically proportional to the diminution in speed and *vice versâ*, as in an electric motor. The experiments were made by counting the speed of the motor under different brake loads, and the following formulæ, deduced from data given in the paper, were employed in calculating the horse-power and mean effective pressure p_m per sq. cm. on the piston during the explosion stroke: h.p. $= 363$ P.n. 10^{-6}, and $p_m = 0{\cdot}435$ P, where P is the brake load in kilogrammes, and n is the number of revolutions of the motor. The results of the tests are expressed in the following table, which shows that the relationship above referred to is practically correct, the deviations from proportionality being due probably to experimental errors in the determination of the speeds.

P	n.	h.p.	p_m
8	1,697	4·9	3·48
9	1,756	5·7	3·92
10	1,544	5·6	4·35
11	1,561	6·2	4·79
12	1,492	6·5	5·22
13	1,410	6·6	5·66
14	1,261	6·4	6·09
15	1,206	6·6	6·53
16	1,120	6·5	6·96

The paper, which gives a comparison of the results with those obtained in similar experiments on other types of motors, is illustrated by curves, and also contains a mathematical investigation of the number of revolutions at which the h.p. is a maximum. The importance of proper adjustment of the carburettor and ignition for obtaining the maximum efficiency of the motor is also pointed out. J. G

1771. *Crowden Petrol Motor.* (Engineer, 93. p. 520, May 23, 1902.)—This is a double cylinder, horizontal engine, in which the pistons are coupled to overhung cranks on a crank-shaft carrying the flywheel at the centre of its length. The bodies and heads of the cylinders are castings, but the water-jacket is formed of sheet metal, and constitutes also the water-tank. The inlet valves are automatic, and the exhaust valves mechanically operated. This operating gear consists of two strikers coupled to the ends of a lever pivoted at its centre. The lever is oscillated by connection to an eccentric pin on a disc geared to rotate at half the speed of the crank-shaft. The ignition is electric. C. R. D'E.

1772. *Blake Motors.* (Automotor Journal, 7. pp. 152–154, May 24, 1902.)—These petrol motors are of the vertical type, having either two or four cylinders. In either case the bodies, heads, and water-jacket of a pair of cylinders form one casting, which is bolted down to the crank-enclosing chamber. The inlet and exhaust valves are placed vertically over one another. The

exhaust-valve mechanism is enclosed, as is also the centrifugal governor which controls the admission of gas to the cylinders. The body of the crank chamber is formed of a single casting, the crank-shaft being inserted by means of circular end doors. High-tension electric ignition is employed. With aluminium crank chambers the 9-h.p. two-cylinder engine weighs, with flywheel, 200 lbs., and the 14-h.p. four-cylinder 300 lbs. C. R. D'E.

1773. *Schmidt Launch Motor.* (Motorwagen, 5. pp. 127–128, April 30, 1902.)—This article describes the launch motor constructed by Messrs. Richard Schmidt & Co., of Leipzig. The motor, which is of the well-known Daimler type, has two cylinders with cranks arranged at 180°, and developes 12 h.p. at 800 r.p.m. The only noteworthy feature in the motor is the formation of the crank chamber as an oil-bath, in which is immersed the gearing between the crank-shaft cam and the two-to-one cam-shaft from which the valves and the cooling water circulating pump are operated. The motor is clearly illustrated, and a table is given showing its principal dimensions.

J. G.

1774. *Gasoline and Kerosene as Fuel for Explosive Engines.* **L. Berger.** (Horseless Age, 9. pp. 630–632, May 28, 1902.)—The author has made some experiments with a gasoline of formula, $41{\cdot}86C_6H_{14} + 6{\cdot}48C_7H_{16} + C_5H_{12}$. He finds that the calorific value of this gasoline is about the same as that of hexane (C_6H_{14}). With air as the source of oxygen for the combustion, the reaction is as follows : $C_6H_{14} + 9{\cdot}5O_2 + 36{\cdot}1N_2 = 6CO_2 + 7H_2O + 36{\cdot}1N_2$. If w be the atomic weight, and c the specific heat of a gas, then according to Berthelot, $cw = a + bt$. For triatomic substances, as CO_2 and H_2O, a is 6·2 and b is 0·005. For biatomic substances, like N_2, a is 4·8 and b is 0·002 ; t is temperature of combustion in degrees Centigrade. Berthelot has also shown that if q represents the total heat liberated in a reaction, then—

$$\int_{t_o}^{t} \Sigma nwc\,dt = q,$$

and, substituting $a + bt$ for cw, we obtain $q = At + Bt^2$, where $A = na$ and $B = \frac{1}{2}\Sigma nb$. For gasoline or hexane we have therefore—

$$A = (6+7) \times 6{\cdot}2 + 36{\cdot}1 \times 4{\cdot}8 = 254,\ B = (6+7) \times 0{\cdot}0025 + 36{\cdot}1 \times 0{\cdot}001 = 0{\cdot}07.$$

In the formation of CO_2 there are liberated 94,300 calories per 44 kg. The formation of H_2O furnishes 58,200 calories per 18 kg. The separation of hexane into its elements requires 19,800 calories per 86 kg. Hence the formation of CO_2 liberates $6 \times 94{,}300 = 565{,}800$ calories, that of H_2O, $7 \times 58{,}200 = 407{,}400$ calories, and the separation of C_6H_{14} absorbs 19,800 calories, leaving a total liberation of 953,400 calories. Consequently, the combustion of gasoline or hexane liberates $953{,}400/86 = 11{,}086$ calories per kg. Substituting in the equation $q = At \times Bt^2$, we obtain $953{,}400 = 254t + 0{\cdot}07t^2$, which gives $t = 2{,}300°$. Average kerosene consists chiefly of decane ($C_{10}H_{22}$). For the reaction which takes place when kerosene is burned the author takes that corresponding to the combustion of decane. The equation will be—

$$C_{10}H_{22} + 15{\cdot}5O_2 + 58{\cdot}9N_2 = 10CO_2 + 11H_2O + 58{\cdot}9N_2,$$

so that—

$$A = (10 + 11) \times 6{\cdot}2 + 58{\cdot}9 \times 4{\cdot}8 = 413,$$

and—

$$B = (10 + 11) \times 0{\cdot}0025 + 58{\cdot}9 \times 0{\cdot}001 = 0{\cdot}111,$$

giving a total of 1,560,000 calories, or 11,000 per kg. The equation for the temperature developed is $413t + 0{\cdot}111t^3 = 1{,}560{,}000$, or $t = 2{,}324°$.

When combustion takes place in a closed vessel, the ratio P/P_o, which determines the power of an explosion, is given by the equation $P/P_o = V_oT/273V$, but $V_o/V = \Sigma no/\Sigma n$, giving $P/P_o = 9{\cdot}93$ for gasoline, and $10{\cdot}08$ for kerosene.

The combustion of 86 kg. of gasoline require $9{\cdot}5 \times 32 = 304$ kg. oxygen, which corresponds to 11,800 cm. of air per kg. gasoline. The volume of 1 kg. of gasoline vapour is 254 cm.; therefore the volumetric ratio of gasoline vapour to air to give the sharpest explosion is $254/11{,}800 = 2{\cdot}15$ per cent. Similar calculation gives the volumetric ratio of kerosene vapour to air $1{\cdot}35$ per cent.

Carburation.—The vaporisation of gasoline requires a surface per h.p. of 221 sq. cm., heated to about 82° C., the pressure of the vapour mixture being 760 mm. of mercury. The gasoline must fall on the surface drop by drop. In the case of spraying carburettors, the velocity of the air must be 25 m. per second; the vaporisation surface can be less than 221 sq. cm. The gasoline vapour diffuses in air with a velocity of 5 mm. per second. Knowing the speed of the suction, it is easy to calculate the openings in the gauze required and the length of suction pipe in order that the gasoline vapour may have time to completely penetrate the air before it is admitted to the cylinder. The vaporisation of kerosene requires a surface of 200 sq. cm. per h.p., heated to a temperature of 220° C., the pressure being 760 mm. of mercury. The kerosene must be thrown drop by drop on the surface. With a kerosene motor running at 720 r.p.m., the total volume of the suction pipe and mixing chamber must be at least four-fifths of the piston displacement. A table is given showing the various properties of the two fuels. C. C.

1775. *Fuel for Automobile Explosive Engines.* **A. L. Clough.** (Horseless Age, 9. pp. 627–628, May 28, 1902.)—The author refers to the Long Island Endurance Test [see Abstract No. 548 (1902)], and regrets that gasoline consumption tests were not brought more into prominence. The gasoline cost in America is only about 3 per cent. of the total cost of running an ordinary automobile. But considering that future improvements in tyres, engines, gearing, &c., must vastly reduce the cost of repairs, the question of fuel consumption should now be considered more seriously. The price of gasoline is rapidly increasing, and its supply is very limited, whereas kerosene is a material of which the supply is practically unlimited, and is much cheaper per unit of energy. More attention should therefore be paid to the carburation of kerosene. C. C.

1776. *Kerosene Carburettors and Burners.* **L. Berger.** (Horseless Age, 9. pp. 637–639, May 28, 1902.)—In the French system of carburation for motors, the kerosene flows through a coiled tube heated by the exhaust, and is afterwards sprayed. Drawings of the Longuemare carburettor [see Abstract No. 1144 (1900)] for kerosene and alcohol are shown, as well as the kerosene carburettors used on the Diedricks and Vosper motors. The author describes burners of Longuemare, Serpollet, Lifu, and Clarkson. C. C.

1777. *Float Feed Carburettor of the Marienfelde (Berlin) Motor-Boat and Motor Manufacturing Co.* (Motorwagen, 5. p. 96, March 31, 1902.)—This article describes the new Marienfelde double-float feed carburettor, which is intended for use with motors employing a mixture of benzine and alcohol. Two chambers, supplied with benzine and alcohol respectively, contain floats for automatically maintaining the liquid in the chambers at constant levels. These chambers are situate on opposite sides of a main mixing-pipe, and

communicate therewith through separate induction nozzles and a two-way valve, the air supply taking place along with the alcohol. The charge supplied to the cylinder from the mixing-pipe is controlled by a throttle-valve regulated from the engine in the usual manner. J. G.

1778. *Napier Induction Valve.* (Automotor Journal, 7. pp. 95–96, May 10, 1902.)—This is similar to the ordinary form of flat-seated, spring-controlled automatic induction valve commonly employed in petrol engines, but in addition to the area opened around the periphery of the valve when lifted, there are four apertures in the valve disc close around the valve stem. Pressure-tight seatings are provided round these apertures, and concentric with the exterior seating. This valve opens nearly 1·5 times more area than the simple disc valve, for an equal lift. C. R. D'E.

AUTOMOBILISM.[1]

1779. *Automobile Cars on Railway Lines.* **Hempel.** (Zeitschr. Vereines Deutsch. Ing. 46. pp. 464–465, March 29, 1902. Paper read before the Bavarian Section, Jan. 18, 1901.)—The author points out that in local railway lines not connected with commercial centres it is not usually possible to run daily with economy more than two trains travelling to and from the terminal stations; and in order to increase the earning capacity of such lines he proposes that motor traction cars should be run to supplement or displace the ordinary trains. After consideration of the various available sources of power for driving the cars, he concludes that a steam-driven car having a Serpollet [see Abstracts Nos. 902, 903, and 1732 (1900)] generator is most suitable. He then discusses the results of trials made with a Serpollet railway car built for the Würtemberg State Railway in 1897. The boiler employed in this case was capable of developing 35 h.p., and worked at a normal pressure of from 15 to 20 atmospheres. It was fitted with a Worthington injection water-pump driven from the engine shaft, and for starting purposes a separate hand-operated pump was provided. The total steam space was 20 litres, as against 160 litres for a locomotive boiler of the same power. The steam was superheated to a temperature of from 350° to 450° C., and special arrangements were adopted to prevent overheating of the boiler tubes when the car was stationary. The superfluous steam from the boiler was employed for heating the car. The chief drawback found in working the boiler was that, in order to prevent incrustation of the narrow steam space, it was necessary to employ very pure water of 5 to 7 degrees of hardness, and even then it was found that an acid solution of 1 in 4 had to be forced through the tubes once a fortnight for the purpose of removing the scale.

The total cost of running the vehicle, exclusive of interest and depreciation, was 23 pfg. per km., which was made up as follows: Fuel, 9 pfg.; attendance, 10 pfg.; and 4 pfg. for repairs. For an ordinary locomotive on a local line the total running expense is stated to be 40 pfg., of which 20 pfg. is required for fuel, 13 pfg. for attendance, and 7 pfg. for repairs. J. G.

1780. *Brake Tests of Automobiles and Horse-drawn Vehicles.* (Horseless Age, 9. pp. 565–567, May 7, 1902.)—Particulars are given of a complete series of tests of the pulling-up powers of automobiles and horse-drawn vehicles travelling at speeds from under 10 m.p.h. to their maximum on a level road.

[1] Electric Automobiles are described in the Section dealing with Electric Traction

Speed Under 10 Miles per Hour.

Vehicle.	Weight. Lbs.	Speed. Miles per Hour.	Stopping Distance. Feet and Inches.
Oldsmobile (gasoline)	600	8·7	8·9
White (steam)	1,350	10	17·2¼
		7·5	6·9½
Locomobile (steam)	1,000	7·8	5·9
Autocar (gasoline)	1,050	9·2	18·1⅛
		9	20·4
		9	17·8⅓
		8	9·10
Waverley (electric)	1,050	9·4	11·5
		8·7	4·4⅓
Toledo (steam)	1,400	7·6	4·9½
Panhard (gasoline)	2,500	9·4	5·11
		6·9	3·10
Gasmobile (gasoline)	2,100	9·2	10·0⅝
		6·7	5
Peugeot (gasoline)	2,100	6·4	4·2
		7·6	7·11½
Friedman (gasoline)	1,000	6·9	7
Packard (gasoline)	2,500	7·2	6·8
Long Distance (gasoline)	1,400	7·6	4·9
Haynes-Apperson (gasoline)	2,000	4·5	4·6

Speed Under 17 Miles per Hour.

Vehicle.	Weight. Lbs.	Speed. Miles per Hour.	Stopping Distance Feet and Inches.
Oldsmobile (gasoline), 2 persons	800	14·4	21·7
Pierce (gasoline), 2 persons	650	13·8	24·0¼
		15·6	33·8½
White (steam), 2 persons	1,350	15·0	31
Locomobile (steam), 1 person	1,000	16·3	30·9
Autocar (gasoline), 2 persons	1,050	14·4	31·8
Waverley (electric)	1,050	13·8	21·5
Toledo (steam), 1 person	1,400	12·8	15·2
		16·3	34
Panhard (gasoline), 2 persons	2,500	16·3	25·4½
		13·8	22·8
Gasmobile (gasoline), 2 persons	2,100	12	9·9½
		15	22·2½
Peugeot (gasoline), 4 persons	2,100	15·6	40·10
Friedman (gasoline)	1,000	8·3	10·2¼
Packard (gasoline), 3 persons	2,500	13·3	26·7
Haynes-Apperson (gasoline), 3–4 persons	2,000	13·8	21·2½
		16·3	36·8
Long Distance (gasoline)	1,400	15·6	25·11½
Riker (electric)	1,500	11·2	43·5

Speed 20 Miles per Hour.

Vehicle.	Weight. Lbs.	Speed. Miles per Hour.	Stopping Distance. Feet and Inches.
Oldsmobile (gasoline), 1 person	600	20	60·6
White (steam), 1 person	1,350	21·1	75·2
Locomobile (steam), 2 persons	1,000	22·5	51·5
Autocar (gasoline), 2 persons	1,050	20	69·3
Toledo (steam), 2 persons	1,400	20	45·8
Panhard (gasoline), 2 persons	2,000	18·9	34·6
Gasmobile (gasoline), 2 persons	2,100	20	34·11½ [1]
Friedman (gasoline)	1,000	17·1	59·9
Mors 3 (gasoline) (8 h.p.)	—	22·5	75·9
Long Distance (gasoline), 2 persons	1,400	18·9	29·2

[1] Car turned completely around in stopping.

TEST UNDER FULL SPEED.

Vehicle.	Weight. Lbs.	Speed. Miles per Hour.	Stopping Distance. Feet and Inches.
Toledo (steam)	1,400	27·6	122·1
Oldsmobile (gasoline)	800	20	58·6
Mors (gasoline)	—	30	125·8
Panhard (gasoline)	2,500	25·7	89·7
Gasmobile (gasoline)	2,100	27·6	114·7
Long Distance (gasoline)	1,400	21·1	60·4½
White (steam)	1,350	27·6	Failed to stop.
Locomobile (steam)	1,000	32·5	139

By comparison a test was made of the braking powers of horse-drawn vehicles and bicycles, as follows :—

Vehicle.	Speed. Miles per Hour.	Stopping Distance. Feet and Inches.
Payne Whitney's four-in-hand	9	25·11¼
Payne Whitney's four-in-hand	16·3	77·6
Payne Whitney's four-in-hand	18·0$\frac{9}{10}$	90·10
Victoria and pair	9	17·7¾
Victoria and pair	13·0$\frac{8}{10}$	36·10
Bicycle (policeman)	9·0$\frac{4}{10}$	8
Bicycle (policeman)	20	61·6
Bicycle (policeman)	27·0$\frac{6}{10}$	31·2

These tests were conducted in New York City under the auspices of the Automobile Club of America. C. R. D'E.

1781. *Kühlstein-Vollmer 60-h.p. Locomotive.* (Motorwagen, 5. pp. 97–98, March 31, 1902.)—The article deals with a traction locomotive of the Kühlstein-Vollmer type [see Abstract No. 2453 (1901)] specially designed for displacing oxen in the transportation of goods over the desert country between the sea-coast and the frontier of German territory in South Africa, a distance of 80 km. The motor has four cylinders, and develops 60 h.p. maximum and 45 h.p. normal, at from 600–900 r.p.m. The diameter of the cylinders is 145 mm. and the stroke 170 mm. The motive power is furnished by petroleum. The wheels of the vehicle are made of large diameter and breadth, in order to enable the hollows in the ground to be easily traversed and to prevent the wheels sinking into the sand. The diameter given is 1·5 m. and the breadth 350 mm., and, where the sand is specially soft, the breadth may be increased to 800 mm. by means of auxiliary rings carried on the vehicle.

A special feature of the vehicle is the large tractive effort which it is capable of exerting. It has a tare weight of 4,200 kg., can carry a load of 7,000 kg., and is capable of drawing four loaded trailers having a gross weight of 20,000 kg. The following tabular statement shows the tractive effort and gear transmission ratios of the vehicle at different speeds :—

Speed in Km. per hour.	Tractive Effort in Kg.		Gear Ratios.
	Normal.	Maximum.	
1·70	2,400	3,100	1·0
3 25	1,800	2,300	1·9
6·00	1,200	1,500	3·5
10 00	600	800	6·0

Where specially steep inclines are encountered, the motor vehicle makes the ascent alone, then anchors, and draws the trailers up the incline by means of a rope. In ordinary cases the trailers are drawn up one by one. J. G.

1782. *Wolseley Cars.* (Automotor Journal, 7. pp. 164–169, May 31, 1902.)—A detailed illustrated description is given of the latest types of Wolseley engines and cars. The engines, single cylinder 5-h.p., double cylinder 10-h.p., and four-cylinder 20-h.p., are all of the horizontal type, water cooled, and fitted with electric ignition. In the 5- and 10-h.p. cars the transmission is by a single Renolds' chain to a spur-wheel change-speed gear, and finally from the differential cross-shaft to the rear road wheels by roller chains. In the 20-h.p. cars a similar mechanism is employed, but the power is transmitted to the change-speed gear by two Renolds' chains. Illustrations of the 35-h.p. racing car are also given. [See also Abstract No. 165 (1902).] C. R. D'E.

1783. *Bardon Car.* (Automotor Journal, 7. pp. 70–73, May 3, 1902.)—The general arrangement of the mechanism in the latest types of Bardon car is illustrated and described. The main features are similar to those of earlier types, the engine in the 12-h.p. car being of the double cylinder four-piston horizontal type with two crank-shafts, and the transmission comprising bevel and spur gear between engine and differential cross-shaft, and chain drives to the rear road wheels. C. R. D'E.

1784. *Napier Lorry.* (Automotor Journal, 7. pp. 126–128, May 17, 1902.)—This is a 5-ton lorry driven by a 4-cylinder petrol engine, capable of developing 24 b.h.p. The main underframe is constructed of channel steel, and towards its front end is mounted the engine. The power is transmitted through a friction clutch to a four-speed change gear, having spur wheels, which are brought into engagement by side contact. A bevel gear transmits from the upper counter-shaft of the change gear to the differential cross-shaft, and the final transmission to the rear road wheels is by independent chain drives. The four forward speeds, and one reverse, are all controlled by a single lever. The steering wheels are pivoted on the Ackerman system, and controlled by a hand wheel operating through a worm and sector gear. C. R. D'E.

1785. *Brazier Gasoline Automobile.* (Horseless Age, 9. pp. 559–560, May 7, 1902.)—This is an American touring car constructed on lines similar to those of many French cars. The engine is of the double cylinder vertical type, fitted with electric ignition, and rated at 18 b.h.p. at 800 r.p.m. It is mounted towards the front of the underframe, and covered by a sheet-metal bonnet. The power is transmitted through a cone friction clutch, with surfaces arranged to eliminate end thrust while the power is on, to a three-speed change gear, and finally, by a flexible tail shaft and bevel gearing to the live rear axle. The car weighs about 2,100 lbs. complete with body. C. R. D'E.

1786. *Daimler Motor Launch.* (Engineering, 73. p. 678, May 23, 1902.)—This article describes a motor launch which has been built for use at Shoeburyness in towing targets to and from their stations during artillery practice. The motor is of the usual Daimler type, and is capable, when running at its full speed of 700 r.p.m., of developing 22 h.p., with a con-

sumption of about one pint of petrol per h.p. per hour. The motor flywheel drives the propeller shaft through a spring clutch coupling, and the propeller is provided with adjustable reversing blades. The contract speed of the launch was 7 miles per hour, but the actual speed attained on its trial trip was between 10 and 11 miles per hour. Four different means are provided for varying the speed of the launch: (1) By altering the angle of the propeller blades while running at constant speed; (2) by regulating the volume of the explosive charge supplied to the engine; (3) by timing the ignition; and (4) by the action of the governor in cutting out explosions. A characteristic feature in the launch is the method of preventing sand and grit from lodging in the stern-post propeller shaft bearing, by enclosing it in a chamber supplied with exhaust pressure gases from the engine. Lubrication is effected by dropping oil into the pipe supplying this chamber, the exhaust gases carrying the oil to the bearing. The arrangement of the propelling mechanism of the launch is clearly shown in the illustrations which accompany the article. J. G.

REFERENCES.

1787. *Wigzell Steam Engine.* **R. J. Isaacson.** (Mech. Eng. 9. pp. 561–563, April 26, 1902. Paper read before the Engineering Society, Oct. 28, 1901.) [See Abstract No. 199 (1901).] H. R. C.

1788. *Evolution of the Shaft Governor.* **C. Carpenter.** (Power, N.Y. 22. pp. 4–7, March, 1902. Paper read at the meeting of the Engine Builders' Ass., New York, Dec., 1901.)—This paper is mainly historical, and contains a list of early United States patents from 1839 to 1880. G. W. DE T.

1789. *Transverse Stresses in Steam-pipes.* **A. S. Mann.** (Amer. Electn. 14. pp. 110–112, March, 1902.)—This is a continuation of a former paper. [See Abstract No. 968 (1902).] H. R. C.

1790. *Circulation in Water-tube Boilers.* **A. C. Elliott.** (Engineering, 73. pp. 495–498, April 18, 1902.)—A theoretical investigation of the water circulation in the Belleville boiler. H. R. C.

1791. *Water-Softening.* (Tram. Rly. World, 11. pp. 235–236, April, 1902.)—This article gives a general account of the treatment of water containing calcium sulphate and magnesium carbonate, but no calcium carbonate, for use in steam boilers. [See also Abstracts Nos. 202, 2233 (1901), and 155 (1902).] F. J. R.

1792. *Gas-Engine Calculation.* **R. Barkow.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1640–1642, Nov. 16, 1901, and 46. pp. 81–83, Jan. 18, 1902.)—Investigations of the average pressures during the different portions of the cycles of gas-engines are here made, and deductions are drawn with respect to the best conditions of action, but these rest on uncertain assumptions. R. E. B

GENERAL ELECTRICAL ENGINEERING.

1793. *Friction and Wear in Toothed Gearing.* **K. Büchner.** (Zeitschr. Vereines Deutsch. Ing. 46. pp. 159–166, Feb. 1, and pp. 278–284, Feb. 22, 1902.)—The teeth are worn away mainly owing to the fact that they slide to some extent upon one another in addition to the rolling motion that takes place; in this way the material is gradually removed as a result of the rubbing. Moreover, in consequence of shocks of various kinds, the teeth become crushed and flattened. The author examines the result produced by the sliding motion of the teeth upon one another. This depends on the normal pressure between the teeth, and on the amount of the so-called specific sliding, *i.e.*, on the proportion which the sliding bears to the travel of the teeth on each other at each instant. A graphic method is given for determining the normal pressure in the case of teeth formed according to Lindner's method, and also on the involute and cycloidal methods. Similarly, the specific sliding is determined by graphical methods in the three cases, and also by analytical methods in the case of involute and cycloidal teeth. The wear on the teeth is proportional to the product of the normal pressure, the specific sliding, and the speed of revolution, apart from considerations of the coefficient of friction and the breadth of the teeth. These products are worked out for the various forms of teeth, and when plotted out constitute the "wear-characteristics," which are very different for the various forms of tooth, the wear being moreover unequal on the driving and driven tooth. The theoretical results do not agree entirely with those obtained practically. This partly arises from the fact that wear causes gradual alterations in the shape of the teeth, and it is not possible to take this into account theoretically. It is nevertheless possible to foresee the probable amount of wear under any given conditions. A general outline is given of the form of toothed gearing used by the Allgemeine Elektrizitäts Gesellschaft. It is of the involute form and the arc of approach is kept as small as possible. The larger wheel has teeth with considerable depth below the pitch line, and a small amount above, whereas the smaller wheel is constructed on precisely opposite principles. Particulars are also given of the gearing used by de Laval in connection with his turbines; the teeth are kept as small as possible, and have a height of 2·7 mm. on a wheel with a pitch circle of 360 mm. diameter. In this way the arc of contact is kept as small as possible. W. H. S.

1794. *Hydraulic Turbine Governor.* (Amer. Electn. 14. pp. 240–242, May, 1902.)—In the Sturgess governor the main gate of the turbine is controlled by a rotary piston which makes 0·87 of a revolution. Water is admitted to one side or the other by means of a piston valve, which is itself moved by hydraulic pressure, controlled by a small central valve connected to a centrifugal governor. In order to check any tendency to hunt, each movement of the main shaft is caused, through the intermediary of a dash-pot, to alter the size of an expanding pulley on the governor shaft. Thus if the speed of the turbine increases, the governor partially closes the gate, but the movement of this latter expands the pulley of the governor, and reduces its speed relatively to that of the turbine itself, thus preventing instability. A. E. L.

GENERATORS, MOTORS, AND TRANSFORMERS.

1795. *Design of Continuous-Current Dynamos.* **R. Kennedy.** (Elect. Rev. 50. pp. 899–900, May 30, 1902.)—The author gives a formula for determining the total magnetic flux through the armature in Kapp lines $Z = \sqrt{\text{kw.}} \times 200$. This assumes a speed of 1,000 for all machines; for a lower speed divide 1,000 by the number required to bring it down to the given speed, and multiply the constant 200 by the square root of this number; for a higher speed multiply 1,000 by the number required to bring it up to the given speed, and divide the constant 200 by the square root of this number. Then the number of turns on the armature $= E \times 10^6/Zn$, where $n =$ the speed. R. B. R.

1796. *Concatenation of Induction Motors.* **E. Danielson.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 439–451, April, 1902.)—With two motors having different numbers of poles, four different speeds are in general obtainable, viz., that due to the natural speed of each motor, that due to the ordinary arrangement in concatenation, and that due to concatenation with the connections reversed. Thus with a four-pole and a ten-pole motor on a 50 ∿ circuit, the four-pole motor alone will give a speed of 1,500 r.p.m., the ten-pole motor alone 600 r.p.m., the ordinary concatenation 428 r.p.m., and the so-called "differential concatenation" 1,000 r.p.m. The application of this principle to traction is discussed, and the following table is given as showing the input required for unit mechanical output with different arrangements of direct-current and induction motors. The full-load efficiency is in every case taken as 92 per cent.

	Accelerating only.		Accelerating and electrically braking.	
	Without gearing.	With gearing.	Without gearing.	With gearing.
Direct-current motor, resistance entirely cut out at ⅜ full speed	1·33	1·4	1·33	1·4
Direct-current motor, resistance entirely cut out at ¾ full speed	1·4	1·48	1·4	1·48
Induction motor, simple	2·17	2·29	2·17	2·29
Induction motors, regular concatenated connection	1·68	1·77	1·36	1·47
Induction motors, three speeds, 0·4 : 0·67 : 1	1·5	1·58	1·17	1·27
Induction motors, four speeds, 0·285 : 0·4 : 0·67 : 1	1·45	1·52	1·15	1·24

A. E. L.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING

ELECTRICAL DISTRIBUTION.

1797. *Economical Loss of Pressure in Conductors.* **A. della Riccia.** (Assoc Ing. Él. Liège, Bull. 2. pp. 20–41, Jan., 1902.)—When the problem is to trans mit power by means of a simple electric line, the economical rule of Kelvin in which the best conditions of working are such that the annual costs o interest and depreciation of the copper in the line are equal to the cost o annual loss of energy in the same, leads to two conclusions, viz. :—1. Tha under these conditions the loss of pressure in the line is fixed, and inde pendent of the pressure either at the transmitting or receiving end, and also of the power transmitted ; it is simply proportional to the length of the line 2. That the density of current is fixed and independent of the pressure chosen of the power transmitted, and of the distance to which it is transmitted When it is a question of feeding a network by means of several feeders, one cannot generally adopt on each of these lines the economical density, because (by conclusion 1) the pressure at each feeding-point would not be the same It is generally arranged that the loss of pressure shall be the same on the different feeders. The author proceeds to show mathematically and graphi cally what is the most economical loss of pressure to adopt in the feeders under such conditions, both for lighting and traction networks ; and discusses also the use of regulating rheostats and boosters. The lead and return feeders are calculated separately for lighting and traction systems, and formulæ given for each. F. B

1798. *Isolated Plants* v. *The Central Station.* (Elect. World and Engineer 39. pp. 817–819, May, 10, 1902.)—This is an abstract of a discussion which took place before the Chicago Electrical Association. **C. A. Dresser,** who opened the discussion, expressed no decided opinion ; he calculated that i an isolated plant had a load of 80 h.p. for 10 hours a day for 300 days in the year, the cost of power, if generated by steam, would be 2.85 cents per kw.-hour, after making a certain allowance for the utilisation of the exhaust steam for heating purposes. **S. M. Bushnell** followed with a lengthy argument in favour of the central station, the main point being that it relieved the consumer from various anxieties. **J. Mabbs** said that the Board of Trade had installed plant for the purposes of their building, and the cost of power was now one half of what it would be with central-station supply, and they practically heated their building free of cost for seven months in the year. Current is sold by meter to tenants on the basis of 10 cents per kw.-hour with a sliding scale which gives a consumer of 1,000 kw.-hours per month a rate of 5 cents per kw.-hour. W. H. S

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1799. *Power Transmission Plant in New Zealand.* **O. Haes.** (Electrician 48. pp. 396–397, Dec. 27, 1901. Abstract of paper read before the Electrica Association of New South Wales.)—The author describes a small plant which derives its power from a fall on the Kaituna River, and transmits it thence

over a distance of 13 miles to the town of Rotorua. There are two turbines, each giving 100 b.h.p. at 117 r.p.m., with a head of 14 ft. These drive 50-kw. alternators by means of belts, the output being given at any pressure between 3,200 and 4,200 volts, and on the single-phase system. The installation was primarily intended to drive some sewage pumps; but in addition a certain amount of lighting is carried out in the town. W. H. S.

1800. *Cincinnati Gas and Electric Company's Light and Power System.* (Elect. World and Engineer, 39. pp. 843–850, May 17, 1902.)—This paper deals with the new power and lighting scheme which has resulted from the consolidation of the interests of the three electric companies formerly controlled by the Cincinnati Gas and Electric Light Company. Instead of supplying energy from four different central stations, the whole supply will now be distributed from a single station, which is that formerly used by the Cincinnati Edison Electric Company, but now considerably enlarged and altered. The bulk of the distribution mains were formerly overhead, but these are now placed underground, except in the outlying portions of the town. The total area to be supplied is 43 square miles, and the greatest distance from the station to which current is transmitted is 8 miles. At present, underground conduits are being laid in 43 miles of streets. Continuous-current series arcs are employed for the street lighting, the 3,408 lamps formerly employed, and yielding a revenue of approximately £17 each per annum, will be replaced by 4,400 enclosed alternating-current series lamps, taking 4 amperes at 75 volts each. For these lamps, the contract price for current is about £14 per annum in the underground distribution districts, and £12 in the outlying overhead supply district. The underground lighting and power network is supplied by direct-current generators at 110 and 220 volts, and the remainder of the current will be generated as 60-cycle three-phase alternating current, with 4,000 volts between each phase, and 2,300 volts between each leg and the neutral wire of the circuit, when star-connected. The arcs are supplied by separate G.E. "tub" transformers, each capable of giving current for 60 lights; and for the outlying districts, the transformers, or the motors, where motors are to be supplied, are delta-connected to the three outer legs of the circuit, without making use of the neutral wire. For lighting, the transformers are connected between the outside legs of the 4,000-volt circuit and the neutral wire. The transformers are distributed so as to maintain the phases of the circuits as nearly as possible in balance. The generating plant will consist of one 2,500-kw. three-phase Bullock alternator and four 450-kw. direct-current generators, and, in addition to the latter, for supplying the underground network at light load periods, two 500-kw. motor-generator sets will be used. These motor-generators are designed to take three-phase current at 4,000 volts, and generate direct current at 300 volts for the outer wires of the low-tension network. The characteristic feature of this plant is the three-phase generator, which is designed for 2,500-kw. normal load, and 3,120-kw. continuous overload. It will generate 4,500 volts between its terminals at a speed of 75 r.p.m. It is the largest machine of the kind in America, having 96 poles, and therefore presenting considerable difficulties in its construction over the large machines operating at the low frequency of 25 cycles usually employed. The design adopted is that of the flywheel type of machine; its external diameter is 34 ft. and its internal diameter 30 ft. Full details of the weights of the several parts of this machine, and the electrical guarantees, are also given. The article, which is fully illustrated, concludes by a description of the card system employed for keeping the station records. J. G.

1801. *The Lighting Plant at Jumet.* **R. Berger.** (Assoc. Ing. Él. Liège Bull. 2. pp. 42–62, Jan., 1902.)—In this commune (which is near Charleroi, Belgium, and is of a diameter varying from 5 to 7 km.) the lighting is on the 3-wire continuous-current system, with overhead conductors, and 440 volts across the extremes; nine feeders with pilot wires are employed, and the neutral conductor is earthed. The generating station contains two 150-h.p. (French) Preud'homme compound condensing engines, running at 85 r.p.m., supplied with steam by three Cornwall-Galloway boilers by Germeau, each having 70 sq. m. heating surface and working at 9 atmospheres; two of them are sufficient for the daily load, the other being used as a reserve. There are two 100-kw. 8-pole belt-driven dynamos giving 500 volts at 365 r.p.m. and two 18-kw. dynamos for the accumulators; these latter run at 1,050 r.p.m., and their voltage can be varied from 250 to 340 volts by means of resistances in their shunt circuits. The switchboard permits the two 100-kw. dynamos to be put in parallel, with the battery, or the 18-kw. equalisers, connected to the neutral point; the network to be fed by the battery alone, or by the two equalisers alone, or by the battery in parallel with the equalisers; the battery is charged by the equalisers, or by the 100-kw. dynamos. The cut-outs are Edison plugs with silver wire fuses. The bare conductors extend from a pole of sheet iron, eight metres high, having □-section rings to receive the insulators. The accumulators are of the Hagen type, with 268 cells, having a capacity of 440 ampere-hours at a 10-hour discharge-rate; 370 ampere-hours at a 5-hour rate (the normal); and 300 ampere-hours at a 3-hour rate. There are 1,340 16-c.p. lamps 40 m. apart, distributed over 66 km. of roads, and 1,800 similar lamps for private consumers are provided for. The calculated loss at full load at the ends of the feeders is 50 volts. The conductors are supported on wooden masts 8·5 m. high, impregnated with cyanide of potassium, and provided with double-bell porcelain insulators. The poles where the feeders join the network have cabins at the base containing switchboards, on which are mounted lightning protectors, fuses, and an electromagnetic switch controlled by pilot wires from the generating station and serving for connecting and disconnecting the street lamp circuit. The price of a kw.-hour for private consumers has been fixed at 0·4 franc for lighting and 0·18 franc for power. C. K. H.

1802. *The Lighting of Bergen County, N. J.* **W. J. Jones.** (Elect. World and Engineer, 39. pp. 899–902, May 24, 1902.)—The lighting is undertaken by a company, which supplies current in about fifty towns, over an area of 16 square miles. Two-phase alternating current is generated at 2,500 volts. Various systems of running incandescent lamps in series for street-lighting purposes are described in outline, nearly all being operated with film cut-outs. W. H. S.

1803. *Hudson Valley Railway.* (Street Rly. Rev. 12. pp. 193–200, April 1902.)—The total length of the line is 103 miles, the track consisting for the most part of 60 or 70-lb. T-rails on ties 6 in. by 6 in. by 8 ft. The trolley wire is No. 000 gauge of figure 8 section. There are five direct-current stations owned by the company, which were taken over at the times when the various companies operating in the district were consolidated. They contain more or less antiquated plant; but it is now proposed to replace them by a three phase 22,000-volt transmission scheme with substations of 300 kw. capacity at intervals of 10 miles along the railway. The plant is to be worked by water power. W. H.

1804. *Grimsby and Cleethorpes Electric Tramways.* (Tram. Rly. World; 11. pp. 285–289, May, 1902.)—The notable feature of this line is that the cars are worked by current obtained from the Grimsby Electricity Works [see Abstract No. 1810 (1901)] when they pass through the streets of the borough, and from a power station owned by the Tramway Company when they pass on to the Cleethorpes section of the system. The tramway line consists, for the most part, of double track laid down to the standard gauge, and is about 6 miles in length. The whole of the track work was carried out by the company's workmen, and it consists of a 6-in. bed of concrete covered with granite paving sets. The girder rails weigh about 90 lbs. per yard, and are, for the greater part, 6½ in. deep. Fish-plates 24 in. long, are secured to the rails at each joint by six 1-in. bolts. Each joint is double-bonded, and cross track bonds are inserted about every 40 yards, whilst the double screw tie-rods are placed every 8 to 10 ft. apart. The tramway and railway crossings have received special attention, and two sets of figures are given, which clearly show how this part of the work has been carried out; whilst two other figures show how the system of feeders, and the pilot and telephone cables have been put down. Three other figures are devoted to the side, and the centre pole systems of trolley wire construction. The whole of the feeder cables are drawn into earthenware conduits, with surface boxes about 100 yards apart. The cast-iron feeder pillars are of rectangular section, and are fitted with two locked doors. By opening these doors, the front and the back of the insulating slab, with all the necessary switches (for the to and from feeder cables) the lightning arrester, and the terminals for the pilot and telephone wires are readily accessible for fixing or adjusting the cable ends, or for merely closing and opening the feeder switches. The company's power-house steam-raising equipment consists of two ordinary double flue cross-tube Lancashire boilers, each 28 ft. long by 7 ft. 6 in. in diameter; a 96 tube economiser, and two feed-pumps, each capable of delivering 4,000 lbs. of water per hour, against a boiler pressure of 125 lbs. All the feed-water piping is in duplicate, and these, as well as the steam-pipes, are made of steel, with screwed-on flanges; whilst the exhaust, and the ordinary water-pipes, are of cast iron. Two horizontal tandem compound condensing steam engines are each capable of developing 250 i.h.p. when running at 200 r.p.m., and each is coupled direct to a 150-kw. continuous current 550-volt generator. The switchboard is of the usual panel pattern, and is fitted with all the necessary switches and instruments for complying with the Board of Trade regulations. Three photographic views are devoted to the engine-room, containing the two prime movers, two generators and the switchboard; whilst one of these shows the very necessary 10-ton travelling crane. The remaining two figures show the entrance curves to and from the car shed, as well as a photographic end view of the latter with its eight parallel rows of stabled cars. The whole forms an instructive example of the traction plant and equipment required by a small provincial town or district. A. J.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

1805. *Magnetic Effect of Leakage Currents.* **E. B. Wedmore.** (Inst. Elect. Engin., Journ. 31. pp. 576–592; Discussion, pp. 592–610, March, 1902.) —Considering the return current of a tramway line, if the whole current

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

returns by the rails, the magnetic effects due to the current in the trolley wire and rails would practically cancel, except in the immediate neighbourhood. When the current returns partly by the earth and at a distance from the trolley wire, the magnetic effects of the current in the latter is not so cancelled. Assuming that the specific conductivity of the earth is uniform and that the return currents enter and leave at points, no part of the vertical component due to the trolley wires and feeders is cancelled by the earth currents. In the immediate neighbourhood of the track the current in the trolley wire will have a considerable horizontal component, but at a distance this will be wholly due to the earth currents. If the current be assumed to enter and leave the earth along vertical wires, a distance d apart, the horizontal component at a point distant r_1 and r_2 from the two points is $\frac{cd}{r_1 r_2}$ in absolute units, c being the current. If the current be fed along a wire between the two points, the vertical component at the point considered is $\frac{c}{l}(\cos\theta_1 + \cos\theta_2)$, where l is the perpendicular distance from the point to the wire, and θ_1 and θ_2 are the angles between the wire and r_1 and r_2 respectively. When, in a tramway system, points are suitably selected at which it may be said that the current enters and leaves the earth, the author finds that these formulæ give quite as accurate results as the more complex formulæ given by Parry [see Abstract No. 2514 (1900)] and Rücker [see Abstract No. 1601 (1901)]. Edler suggests [see Abstract No. 208 (1900)] that the return currents are carried by a layer of damp ground extending only a small depth below the surface. The formulæ would be equally applicable if this were the case. The author gives values of the horizontal and vertical magnetic components obtained from actual measurement, and compares these with the calculated values. The distribution of current in the earth cannot be calculated until it be known whether it flows in a plane of relatively small thickness or through the body of the earth. If all the resistance between two points on the rail be assumed to be that offered by the earth, the specific resistance of this can be calculated. From his measurements the author finds this to be 75 ohms per cubic yard. He gives the following formula for the apparent resistance to the body of the earth offered by a pipe of radius r per square inch of pipe surface: $R = 6{,}000\, r\,(3 - \log r)$. The author shows that by connecting pipes to the rails no current need leak from the pipe; the pipe, however, will carry a larger current, which may leave or re-enter the pipe at the joints. His recommendations are to use cast-iron joints, to avoid all connections with the rails, and to introduce as far as possible resistance in the joints and on the pipe surface.

Discussion.—**R. T. Glazebrook** gave a table comparing the figures deduced from his theory with those from Edler's experiments; the vertical component only is given, and it is stated that the agreement is not so good in the case of the horizontal component. **A. P. Trotter** described some experiments made in the neighbourhood of Cape Town on normal earth currents and leakage currents from the tramways. The former could often be reversed in direction by wetting the ground near one earth-plate. He is inclined to think it better to connect pipes with the rails, and does not believe that under English conditions the current in the pipe would be increased to the extent Wedmore supposes. He finally describes models showing the equipotential lines and lines of flow when current is fed into one side of a uniformly conducting sheet and tapped at different points. **E. O. Walker** stated as his experience that the earth is practically non-

conductive for 4 or 5 ft. down, and that the good conducting strata are the water-bearing strata 30 or 40 ft. down. If current passes out from a pipe it will gradually decrease owing to the formation of a layer of oxide. He thinks the damage done by chemical action is much larger than any due to electrolysis. **H. M. Sayers** referred to a tramway where the conductivity of the track varied considerably with the state of the weather. He considers it inadvisable to connect the pipes and rails unless the pipes have been laid in such a way as to ensure good electrical contact at the joints. In laying pipes for tramway feeders he does this, and connects the pipes to the rails. **W. M. Mordey** pointed out that though pipes have been said to suffer from electrolysis only since tramways started, yet there always existed earth currents ; he has worked a motor from these in the early days of telegraphy, and has found differences of potential of over 40 volts in 17 miles. G. H. B.

1806. *Automatic Block Signals on the Pennsylvania Railroad.* (Railroad Gazette, 34. pp. 355–357, May 16, 1902.)—Practically there are automatic track-circuit block-signals all the way from Jersey City to Paoli, about 104 miles, and the line is almost entirely four-track. The block sections are all less than 1 mile long, and, in addition to the block signalling, the stations and yards are nearly all equipped with complete interlocking apparatus. Switches, which are not connected with a cabin, and interlocked, have electrical connections to short-circuit the current of the track battery whenever the switch is not set straight for the main line, thus putting signals to "stop" at entrances to block sections. Semaphores are normally at "clear." Each becomes horizontal immediately after the locomotive passes it. All the block signals are Westinghouse electro-pneumatic. The newest features of the system are shown between Philadelphia and Paoli, 17 miles. Signals are on steel bracket-posts at the side of the road. The power is compressed air, but electric current is supplied by a storage battery of 2 cells at each post, an iron box at the base containing battery and relays. The dynamo for charging is at Radnor, 13 miles from Philadelphia, and the feed-wire, No. 6 copper, insulated, is on poles. The batteries supply current for the track-circuits as well as for the signal instruments. At Radnor also are the air compressors. The power, which is mostly used for pumping water to tanks, is furnished by two 125-h.p. locomotive boilers ; the compressors are Ingersoll-Sergeant Duplex, with compound air-cylinders and inter-cooler in base. The dynamos are 500-volt Westinghouse shunt-wound, directly connected to Westinghouse engines, each of 12½ h.p. Bracket-posts are used instead of bridges, because the stations are so close together, and in order to put the signals in the most suitable positions for starting at the stations. The longest section is only 1,327 yards. The main air-pipe is laid in the ground between the two inner tracks. The air and electricity only require a small part of the power provided at Radnor. The interlocking apparatus (mechanical) for the switches and signals at the principal stations existed before the automatic signals were put up. The signals are on bridges, each over the track to which it relates. They have been made "semi-automatic" by attaching a pneumatic air cylinder to each main line high-speed semaphore, and introducing a track circuit with the usual relay : the controlling wires run to circuit breakers on the different switch and signal levers in the cabin. The leverman is thus enabled to "clear" the signal when the track is clear, and the train in passing puts it to "danger." In the New York division, 90 miles, the signalling is similar to that described above. Each block section is worked by a single track-circuit, usually 3,000 to

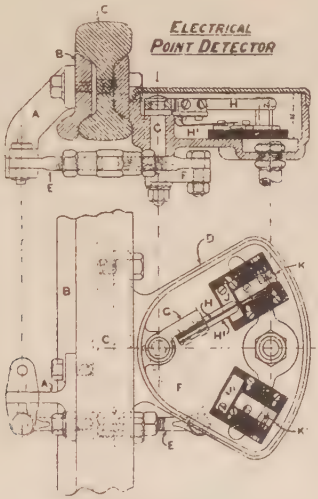
4,000 ft. long, with a home and a distant signal at the entrance of each section. For interlocking, there are 36 plants of the Saxby and Farmer improved mechanical or manual type, and 4 Westinghouse electro-pneumatic, with a number of others, under construction. Compressed air is supplied from a 2-in. main pipe along the whole line. The compressors in continuous service average about 11 miles apart, and are at water and coal stations; there are 6 reserve compressors. There are in all 1,856 signals. The wires are underground, and served during a severe storm last winter to keep the system in regular operation when overhead circuits were crippled. A polarised or wireless system of control is in use on about 20 miles. Pressure recording gauges for the main air-pipe are located at convenient points. Through-trains overtaking local stopping trains on a passenger track are, when possible, shifted over to a freight track. In such a case the despatcher would simply direct the operator where the local train happens to be, to move the through-train from the one track to the other, which he would do by setting the proper cross-over and signals. The through-train, without stopping, would then run from No. 1 to No. 2 track, the local train continuing on No. 1. The former would be brought back to No. 1 track at the next possible place without stopping and without the issue of any orders, the signals directing the movements, and the interlocking and block system providing full protection for both trains at every step of the journey. Where there are no telegraph offices, telephones have been established at the signal bridges, connected to the nearest interlocking towers for prompt report of any unusual occurrence. The safety of the system was tested in an unusual storm last winter, when all telegraph wires were out of use. For 30 hours the trains ran absolutely by the automatic block signals, aided by the operators at the interlocking towers. E. O. W.

ELECTRIC LAMPS AND LIGHTING.

1807. *Knewe Enclosed Arc Lamp.* (Electrician, 49. pp. 50–51, May 2, 1902.)—In this lamp there is only one globe, and the upper carbon holder is made in the form of a split cap to be sprung on to the top of the upper carbon. This cap bears a piston-shaped series of copper gauze washers which slide in a central metal tube through which the current passes to the upper carbon. The middle part of the upper carbon is centred by means of the ring clutch, which is made externally in the form of a ball, to fit easily into the central metal tube. This clutch rests at the bottom on a collar secured to the the lamp-frame, and is provided at the side with an arm connected to a lever controlled by the regulating solenoid of the lamp. The lamp is trimmed through a 3½-in. hole at the bottom of the globe. C. K. F.

1808. *Electric Signalling. W. R. Sykes' System.* (Tram. Rly. World, 11 pp. 292–295, May, 1902.)—The system as used on the Waterloo and City Railway was described in Abstract No. 2042 (1901). It is worth while, however, to reproduce the drawing of the point detector which plays so important a part in lock and block, and to explain the same briefly. All facing points are fitted with this device, which is easily fixed and maintained. It is placed in a fan-shaped cast-iron case, one being fixed to each stock rail on a pair of points, and connected and working with the tongues. A is a crank-arm bolted to the tongue B, C a stock rail, D a cast-iron case, F and G cranks attached to springs H H′, which connect with contact-plates J and K in one direction, and J′ K′ in the other. When the tongues of the points are properly home (the

detector can be so adjusted that these tongues must be actually dead home before it is operative), the springs H H mounted on the crank G would be in contact with the plates J and K, completing a circuit through both detectors, and releasing an electric lock on the tappet of the lever working the signal.



Point Detector.

controlling these points. If now the points are pulled over, the springs H H' would come in contact with J' K', completing a circuit, and unlocking the lever working the signal for this direction. If both tongues are not properly home, the circuit remains broken, and the signal-lever is locked by the electric lock on the tappet. E. O. W.

REFERENCE.

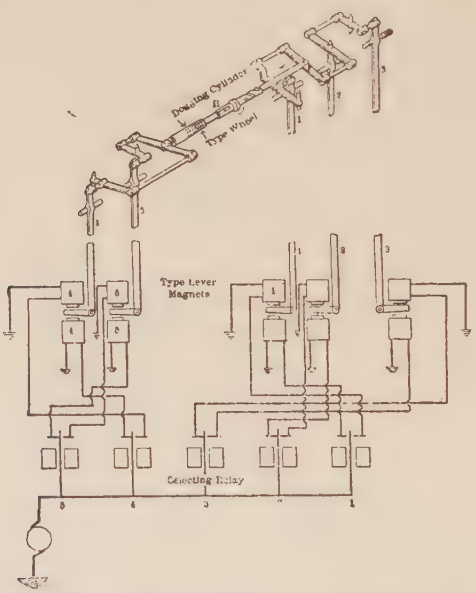
1809. *Conversion to Overhead Trolley System of the Englewood Storage-Battery Road.* (West. Electn. 29. pp. 216–217, 1901.)

TELEGRAPHY AND TELEPHONY.

1810. *The Buckingham Long-Distance Page-Printing Telegraph.* **W. Maver Jr.** (Elect. World and Engineer, 39. pp. 902–908, May 24, 1902.)—To save the time involved in revolving the type-wheel, often the greater part of a revolution, in order to print some letters, as in ordinary type-printers, and to reduce the number of pulsations of current to the lowest number possible: the inventor, C. L. Buckingham, employs four very small octagonal type-wheels, mounted side by side on one shaft, on the periphery of each of which wheels are placed eight letters and other characters. The shaft is so disposed that, by an ingenious arrangement of five levers, it may be given both a lateral and a rotary motion, such that any one of the thirty-two characters may be placed before a given point for printing by five pulsations of current —that is, two and a half alternations of polarity—from the transmitting station. At the receiving station, a succession of five short pulsations always brings the escape wheel to the unison position. For the actual printing of a letter, the pulsation required to produce the space between letters and words in the Morse and Wheatstone systems is utilised, but for the selection and printing, there is a cycle of six pulsations in all. The space, as in Wheatstone's system, is made by a negative current. The alphabet is so arranged that the letters that occur most frequently involve few prolonged impulses. Time is saved in this way. For preparing a tape, a keyboard perforator is used, an improvement on the Wheatstone perforator, inasmuch as the operator has only to depress one key to effect perforations for one letter. The rate at which a Wheatstone puncher can be operated is from twenty to forty words per minute, but in Buckingham's system a skilled operator can do eighty words. When a key is pressed, it makes contact by means of inverted stirrups fixed underneath it, with stretched wires which work crank levers, the latter bringing certain electromagnets into play. These latter operate the punches, of which there are sixteen, eight in each of two rows: one row for the upper, and one row for the lower holes in the tape. A key will cause six punches to work, making three upper and three lower holes in the exact order required for the transmission of the letter to which the key belongs. The central holes in the tape are prepared in advance at high speed in a separate machine. As the letters are of variable length, a variable tape feed is effected automatically by a drum carrying small teeth, which engage the central holes of the tape. The drum is on a vertical shaft, driven by a motor-wound barrel spring. Round the edge of the drum are movable pins. One of the pins is always raised above the normal, and engaging a stop prevents the drum going round. When a key is pressed, a "feed" magnet forces up another pin at an appropriate distance from the first, and on release of the key, another magnet causes a hammer to strike down the first pin, letting the drum revolve till caught by the second pin, and the punched paper is thus pulled through the proper distance. There is a device for indicating the end of a line to the operator, who then depresses a line space key. The method of transmission is identical with that of the Wheatstone Automatic. To avoid the delay that the movement of a paper carriage would cause, the inventor has a novel device in arranging the telegraph blanks at the receiving station in the form of a tube, which is placed loosely over a fixed tubular

support ; along the margin of the blanks is a row of small holes in which a star-wheel engages. This wheel is motor-wound and clock-spring driven, but its movement is controlled by the printer escapement. For advancing the tube of paper at the end of a line, there is a slanting groove within, which guides the star-wheel to a new set of perforations. There is, for receipt of signals, one main line polarised relay, whose armature controls two branch circuits, in which are the escapement magnet, the unison magnet, and the governing relay. These have each two coils reversely wound. The armature of the first oscillates with that of the main line relay. The second is polarised, and its armature is controlled by a spring, so that only prolonged negative currents will affect it. Each letter is followed by such a current, and the hook connected to this armature thus controls the unison wheel, which is on the same shaft as the escape wheel. The spring of the governing relay is arranged to allow the armature to respond to prolonged pulses of either polarity. There are six circuit-closing levers, actuated successively by teeth of the unison wheel, five of them communicating with selecting relays through the armature of the governing relay. These selecting relays work the type-wheel magnets. The sixth circuit-closing lever works the sixth pulse relay, which is concerned with the restoring relay, the press magnet, the feed magnet, an ink-ribbon magnet, and a dogging magnet ; this last serves to lock the type-wheel in a given position, by a pin engaging in holes in a cylinder until the printing is effected. Whenever, in the course of the incoming six pulses that represent and print a character, one or more of the pulses are prolonged, there will also be a prolonged pulse or pulses in the local circuit of the governing relay, which will move its armature. Supposing it is the first pulse. Lever No. 1 is on a tooth of the unison wheel, and pressed against No. 1 contact post. No. 1 selecting relay is in circuit with the dynamo, its armature is thrown over, and causes type-magnet No. 1 to work. This last moves the type-wheel into a position for printing a letter corresponding to a first long pulse. In the inventor's code this is A. If there be no other prolonged pulses in the cycle up to the sixth pulse, the letter A will be printed by the sixth pulse. Had the third and fifth pulses also been prolonged, the third and fifth selecting relays would have been operated, with the result that the letter K would have been printed, as, in the code adopted, this letter consists of three dashes separated by spaces equal to dots. The type-wheel has to assume any one of thirty-two positions, and the mode by which it is caused to do this is so ingenious and novel that it deserves to be explained at length by aid of a diagram. The type-wheel is securely mounted with the dogging cylinder on a horizontal shaft. This shaft receives an endwise motion from the horizontal levers on the left, and a rotary motion from those on the right. In shop phrase, these horizontal levers are termed whiffletrees. The vertical arms 4, 5, connected with the type-lever magnets 4, 5, move the horizontal levers which give the endwise motion to the type-wheel. The arms 1, 2, 3 move the right-hand levers, which impart, by suitable intervening mechanism, the rotary motion to the type-wheel. The whiffletrees are connected by suitable links and pins to their respective arms, and are so pivoted and interlinked that a movement of arm 5, for example, to the right, will move the type-wheel (whose shaft is attached by a swivel connection to the left-hand levers) a distance equal to the width of one of the type-wheel rings to the left. When arm 4 only is moved, it shoves the type-wheel shaft lengthwise a distance of two rings of the type-wheel to the right. When both arms are moved, the type-wheel is moved a distance equal to one ring to the right. As in the normal position of the type-wheel, the second ring from the right is in the

printing position, it is clear that either of the other three rings may be brought into a printing position by the single and combined effects of two endwise adjusting arms. The lengthwise or reciprocal movements of the right-hand levers impart a rotary motion to the type-wheel shaft by the intermediary of a spiral slot in a sleeve through which a pin attached to a rod *R* projects. This rod is connected by a link to the right-hand whiffletrees. The type-wheel shaft enters the left end of the same sleeve, in which it moves freely lengthwise. A pin on this shaft projects through a straight slot in such manner that when the sleeve rotates in either direction the pin compels the type-wheel shaft to turn with it. The rotating levers are so adjusted that arm 1, when moved alone to the left by its magnet, will turn the type-wheel as a whole one-half of a revolution in the direction of the arrow shown at the shaft. Arm 2, when moved alone to the right, turns the type-wheel two-



eighths of a revolution in an opposite direction. Arm 3, moved alone to the right, turns the type-wheel one-eighth of a revolution in the same direction as arm 2. Arms 2 and 3, acting together, jointly turn the type-wheel three-eighths of a revolution in a direction opposite to the arrow, while arms 1 and 2, acting together, but oppositely, will turn the type-wheel two-eighths of a revolution in the direction of the arrow; and by these means any one of the characters on the type-wheel may be placed in the position for printing, with a maximum of five prolonged pulses, apart from the final prolonged negative pulse for printing and restoring the apparatus to normal after printing. Between New York and Chicago, 974 miles, with Wheatstone repeaters at Buffalo, on overhead copper circuits duplexed, the Buckingham system deals with one hundred average messages per hour in each direction. E. O. W

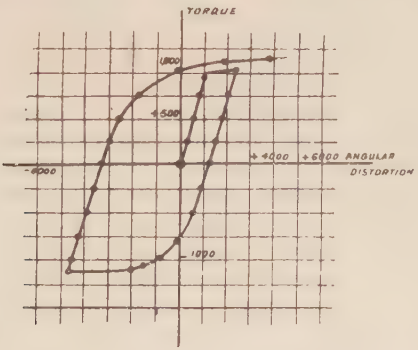
SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

OCTOBER 1902.

GENERAL PHYSICS.

1811. *Iron and Steel under Torsional and Combined Stresses.* **E. G. Coker.** (Roy. Soc. Edinburgh, Trans. 40. pp. 263–293, Nov. 12, 1901.)—Accurate work on the torsion of iron and steel has generally been limited to wires; and in these, want of roundness, and the hardening due to the drawing, would have an effect on the behaviour of the specimen. By means of his apparatus for accurately measuring torsional strain, the author has made a series of experiments on turned bars of about $\frac{1}{2}$ in. diameter, subjected to pure torsion and to torsion combined with tension or with bending. The form of the stress-strain curve for pure torsion, and especially the form at the yield-point, were first



investigated; according to the usual theory, if the material changes from the elastic to the plastic condition at the yield-point, the maximum torque which the bar will stand, when it is all plastic and subject to the same shearing stress, is four-thirds the value at which the first marked deviation from perfect elasticity occurs, for if q be the shearing stress which obtains throughout the bar in the first case, and at the outer layers only in the second case, $T_1 = \frac{2}{3}\pi q r^3$ and $T_2 = \frac{1}{2}\pi q r^3$. With an iron bar, the deviation occurred at 375 in. lbs., and failure at 525 in. lbs., ratio 1·4; a steel specimen gave 675 and 870, ratio 1·29. The phenomenon of breakdown and subsequent recovery from overstrain is similar in torsion to that in tension, such a moderate heating as 100° C. having a marked effect in promoting the recovery. The diagram shows the result

of an experiment on twist in alternately opposite directions on a wrought-iron specimen 0·634 in. diameter, length under test 4 in. The stress-strain curve is approximately linear until the yield-point is reached; the return curve is less so, but, as soon as torsion is applied in the negative direction, the linearity disappears. Breakdown occurs at about 1,100 in. lbs. On reversing the torque again, the curve is again linear until zero torque is reached, when it begins to bend over. The process was continued; each cycle having a hardening effect upon the bar, widening its limits of endurance with a final limit of 1,750 in. lbs., which was reached after fourteen reversals of the stress; the bar was now found to be cracked in several places along the minute seams of impurities. This experiment demonstrates that the limits of elasticity do not remain in their original positions, since stress carried beyond the elastic limit in one direction reduces the other limit to zero. The theory that a twisted bar is twice as strong to resist torsion in the same direction as in the opposite one is not borne out by the experiment. The idea that the distance apart of the elastic limits is a constant, appears to have no physical basis for iron in torsion. The effect of tension on torsion is next examined. A tension within the elastic limit has practically no effect on the elastic part of the torsion curve, but causes a distinct lowering of the yield-point. Two precisely similar pieces from the same bar were used, and a tension of 17,900 lbs. per sq. in. lowered the yield-point from 385 to 360 in. lbs. A specimen of steel was examined both before and after having a tensional stress beyond the elastic limit, producing a permanent set of 0·18 in.; its behaviour was quite linear at the first test, but the tensional overstrain entirely altered its torsional properties, for the second curve begins to bend over at a very low torque. The effect of torsion on tension was only examined below the elastic limit, Ewing's extensometer being used to measure the tensional strain. No difference was observable, whether the bar were twisted or not, provided the elasticity of the bar remained unimpaired. Bending within the elastic limit caused, like tension, a very slight diminution of the strain per unit torque. Bending beyond the elastic limit caused a rise in the strain per unit torque, much greater than the previous diminution. A bar bent within the elastic limit, and tested by twisting beyond the elastic limit, was found to have its yield-point considerably lowered, and the effect of the torque was to give the bar a permanent set in bending under the same moment to which it had previously been elastic. Copious diagrams of the apparatus and of the results of the experiments are given. H. R. C.

1812. *Maximum End Thrust Consistent with Stability for Rods fixed at several Points.* **F. Wittenbauer.** (Zeitschr. Vereines Deutsch. Ing. 46. pp. 501–504, April 5, 1902.)—The author begins by giving a new method of deducing Euler's well-known equation for the stability of a strut, assuming the end thrust symmetrical. The rod may be fixed at any number of points. He supposes the rod to receive a sideward disturbance at any point, equivalent to a statical force Q. Then the deflection at that point, in consequence of Q and the end load P, he shows to be always of the form $f = iQM/m^3N$, where $i = 1/EI$ and $m = \sqrt{P/EI}$, E denoting the Young's modulus of elasticity and I the least moment of inertia of the (constant) cross-section. Further, if $l_1\ l_2\ l_3$, &c., are the lengths between the fixed points of the rod, a the distance from a fixed point of the point of application of Q, and if we put $ml_1 = \lambda_1$, $ml_2 = \lambda_2, \ldots, ma = \alpha$, then M is a function of $\lambda_1, \lambda_2, \ldots, \alpha$ and therefore involves the position of the disturbing force Q, while N is a function of $\lambda_1, \lambda_2 \ldots$ but not of α. If Q is infinitesimally small, then the deflection f

will be indeterminate, provided $N = F(\lambda_1, \lambda_2 \ldots) = 0$. This last equation enables m to be calculated, whence, from $m = \sqrt{P/EI}$, we obtain the thrust P, which, even for infinitesimal disturbance Q, gives a deflection of indeterminate amount. The advantage of the method is its facility of application to rods fixed at several points. The author illustrates by applying the method to two well-known and five new examples. W. S.

1813. *The Navipendulum.* **G. Russo.** (Engineering, 73. pp. 520–524, April 18; and pp. 590–593, May 2, 1902. Paper read before the Institution of Naval Architects.)—This paper deals with an experimental method of ascertaining the rolling of ships on waves, the process being founded on the principle of mechanical similitude. The first part of the apparatus is the "navipendulum"; it consists of a pendulum of special shape, and represents the vessel; artificial resistances are added to it till experiment shows that the loss of amplitude in each oscillation is the same for the navipendulum as for the vessel which it represents. The rolling of the pendulum on a fixed horizontal plate represents the rolling of the vessel in still water. The inclinations of the navipendulum are transmitted to a registering apparatus by means of a system of articulated pieces designed so as not to affect the free oscillations of the navipendulum, and introducing only very slight resistances. The second part of the apparatus is the wave-motion apparatus; the plate on which the pendulum rests is given a motion which corresponds on a reduced scale to that of a portion of the surface of the wave, considered as trochoidal; the construction of this apparatus is described in a paper read by the author at the 1900 spring meeting of the Institution of Naval Architects. The method of using the apparatus is fully described, and the interpretation of its indications critically discussed. Full results are given for navipendular experiments relating to the Royal Italian battleships *Re Umberto* and *Regina Margherita*, and to H.M.S. *Revenge*, ships of three different classes. The indications of the instrument have proved reliable. W. S.

1814. *Rotation of Lamina in Air Currents.* **A. Mallock.** (Nature, 65. p. 510, April 3, 1902.)—Angular velocity = const. × air speed v/breadth of lamina b. Very small laminæ (goldleaf 0·1 × 0·02 or 0·03 in.) do not revolve, but oscillate as they fall through air. The cause of the rotation depends on the way in which the eddies are formed on the downstream side of the lamina; the spin causes the air to flow unsymmetrically with regard to the axis of the lamina. For more than half the total time the rotation is being accelerated. A. D.

1815. *Reduction of Observation Equations.* **W. H. Keesom.** (Konink. Akad. Wetensch. Amsterdam, Versl. 11. pp. 14–19, May 31, 1902.)—This paper deals with the method of least squares for the case of several observed quantities occurring in the equation, the mean result being that from the observation equations reduced to a linear form:—

$$X_1 x + Y_1 y + Z_1 z + \ldots F_1 = 0,$$
$$X_2 x + Y_2 y + Z_2 z + \ldots F_2 = 0, \text{ \&c.,}$$

the normal equations may be deduced in a manner analogous to the case in which the quantities $F_1, F_2 \ldots$ are taken directly from observations. In those equations $X_1, Y_1, Z_1 \ldots$ are a set of approximate values of $X, Y, Z, \ldots, x, y, z, \ldots$

are the corrections to be found, F_1, F_2, are special values of F, where the equation—

$$F(L, M, N, \ldots ; X, Y, Z \ldots) = 0,$$

represents the relation between the quantities L, M, N . . . , as measured directly, and the quantities X, Y, Z . . . , to be calculated. The mean error is found by the usual method. A. G.

1816. *A Numerical Relation between Light and Gravitation.* **V. Wellmann.** (Astrophys. Journ. 15. pp. 282–286, May, 1902.)—The author has attempted to explain the Newtonian law of gravitation by means of a gaseous ether of extreme tenuity, whose particles possess velocities of the order of the velocity of light. [See Wellmann, Astronomische Nachrichten, 144. p. 121, 1897, and 148. p. 169, 1899.] The Newtonian law has, on this supposition, to be modified if the attracting masses are in relative motion. The modifying factor is very nearly unity, and it involves the velocity of the ether particles, V. The author assumes in the present paper that V is equal to the velocity of light in vacuo, and hence deduces the so-called "factor of gravitation." It is found to be in numerical agreement with the constant of Gauss. The author says that the agreement is so close that "a merely accidental coincidence of the two values is out of the question, and a causal connection between light and gravitation seems to be expressed in the figures." W. S.

1817. *A New Hygrometer.* **E. Salvioni.** (N. Cimento, 3. pp. 390–392, May, 1902.)—The author describes a saturation hygrometer which may be used for determining the tension of aqueous vapour in the air in small spaces, such as instrument cases : a portion of the air to be examined is withdrawn and saturated with aqueous vapour, and the increase of pressure thus caused is noted ; knowing the saturation vapour pressure, we can then deduce the aqueous vapour pressure of the experimental air. The apparatus consists of a bronze receiver fitted with a thermometer : into the receiver passes a glass tube drawn out at the lower end and connected at the upper end with a syringe which serves to force in drops of water. The receiver may be put in communication with the exterior air, and carries at the side a graduated tube of 3·2 mm. diameter, containing a column of petroleum 2·5 cm. long. The tension of aqueous vapour in the air enclosed in the receiver is equal to $B_0 - (\iota - \gamma\delta + \mu X)(B - T)$, where B and B_0 are the final and initial atmospheric pressures respectively, X is the displacement of the petroleum column, δ is the change of temperature during the experiment, $\gamma = 0{\cdot}0037$, μ is the ratio of the volume of 1 cm. of the side tube to that of the receiver. D. H. J.

1818. *Demonstration of Change of Pressure with Change of Altitude.* **E. Salvioni.** (N. Cimento, 3. pp. 389–390, May, 1902.)—A cylindrical receiver of sheet metal, of the capacity of 1 to 3 litres, is immersed in a bath of water, and carries horizontally a tube of small section containing a column of petroleum. To conduct an experiment, the division opposite the end of the petroleum column is read when the apparatus is at a certain height (division b_0), again, when it has been raised through, say, 1 metre (division a_1), and again, when it has been brought back to the original altitude (division b_1). If readings are made at equal intervals of time the displacement will be $\frac{b_0 + b_1}{2} - a_1$. The theoretical displacement $= \frac{T - 1}{m}$, where $T = p_1/p_2$, if p_1 is the pressure at the lower position, p_2 at the higher position, and m the

ratio of the volume of 1 cm. of the side tube to the volume of the receiver. The experiments made showed a concordance with the theory for isothermic dilatations and contractions. This concordance shows that with the arrangement adopted, the contractions and dilatations are not adiabatic, but strictly isothermal. D. H. J.

1819. *Mountain Masses and Latitude Determinations.* (Nature, 66. pp. 80–82, May 22, 1902. "The Attractions of the Himalaya Mountains upon the Plumb-line in India. Considerations of Recent Data," by **S. G. Burrard.**)—The principal reference station for latitudes in India is Kalianpur, lat. 24° 7′ 11·10″. From an examination of 148 stations available for geodetic investigations, General Walker had concluded that this latitude was too great by 2″, and that the plumb-line was there deflected to the south in reality, and not to the north. Since then, latitude determinations have been completed by L. Conyngham for four stations about 9 miles, and for four more about 35 miles from Kalianpur. The resulting deflections, both in the meridian and in the prime vertical, do not confirm Walker nor the assumption of any direct influence of the Himalayas. Burrard further discusses the influence of the oceans on the derived longitudes, and comes to the conclusion that the Indian observations favour the Clarke spheroid. H. B.

1820. *Wind Velocity and Fluctuations of Water-level on Lake Erie.* **A. J. Henry.** (U.S. Weather Bureau, Bull. 262. pp. 11–22, 1902.)—The longitudinal axis of Lake Erie, which has a length of 250 miles, approximately coincides with the direction of the predominating winds from the west and south-west. The paper reproduces the hourly records of wind direction, velocity, and lake levels for the year ending November 30, 1900, concerning the two stations, Amherstburg at the western extremity, and Buffalo at the eastern extremity of the lake. Wind measurements are not made at Amherstburg. [See Abstract No. 2137 (1900).] Particulars are given of the three great storms of Dec. 12, 1899, Sept. 12, 1900 (the Galveston hurricane), and of Nov. 21, 1900, the worst storm of that year, when the wind velocity reached 80 miles, and the water rose at Buffalo by 8 ft. 4 in. between 6 a.m. and 4 p.m. The water generally recedes as soon as the maximum wind velocity is passed. Rhythmic wind gusts favour a rocking motion of the water; a characteristic case occurred on August 21, 1900, when the wind velocity fluctuated between 11 and 17 miles per hour. Continued rockings were observed on the days September 12 to 15. The rare easterly winds produce a comparatively strong effect; the reasons for this peculiarity are not discussed. H. B.

1821. *Dust-Falls and their Origins.* (Nature, 66. pp. 41–42, May 8, 1902. From the Abhandlungen d. Kgl. Preuss. Meteorolog. Instit. II. No. 1, by **G. Hellmann** and **W. Meinardus.**)—Comments on the authors' memoir: "The Great Dust-Fall of March 9 to 12, 1901, in North Africa, Southern and Central Europe." Coarse particles fell in Algiers and Sicily without rain, finer particles later in Italy, the Alps, Austria-Hungary, Germany, Denmark, and Russia, in the order named, only with rains, to the total amount of about 1,800,000 tons, two-thirds of which mass was reported south of the Alps; the distribtion was irregular in streaks and patches. The dust was neither cosmic nor volcanic, and is traced back to dust-storms that occurred in the desert of El Erg, Southern Algeria, on March 8 to 10. H. B.

1822. *Mont Pelée Eruption and Dust-Falls.* **W. J. S. Lockyer.** (Nature, 66. p. 53, May 15, 1902.)—The eruption occurred on May 8, where Martinique lies in a low-pressure belt between two high-pressure areas over the Atlantic and South America, and where the sun culminates near the zenith. The ascending air-current from the low-pressure belt would carry dust with it, which, re-descending over the high-pressure areas in a spiral moving clockwise over the middle Atlantic, would reach Great Britain with a south-west wind. We might, therefore, hear of dust-falls and remarkable sunsets in this country. H. B.

1823. *Motor driving for Astronomical Cameras.* (West. Electn. 30. p. 322, May 10, 1902.)—This is a reprint of a part of the report presented by **A. E. Burton** to the Massachusetts Institute of Technology on the eclipse expedition to Sumatra on May 18, 1901. The photographic instruments used at the camp were driven by a simple method of gearing from a controlled motor, the method of control being designed by W. P. Gerrish, of Harvard College Observatory. The main driving motor is geared to a spindle intended to make one revolution a second, and this is provided with a commutator. In the motor circuit are brushes bearing on this commutator, and also the tapper of a relay. The relay is actuated by an adjustable pendulum with mercury contact and subsidiary battery, the closing of the relay allowing the main battery circuit to actuate the motor. It will be seen then that the motor can only be fed with current when the pendulum is swinging in unison with the revolving commutator. Although the motor is thus driven by a succession of impulses, it was found possible to maintain an exceedingly uniform motion of the driving screw, and the arrangement therefore appears to be of extreme utility for these expeditions in regions away from fixed observatories. C. P. B.

1824. *Total Solar Eclipse, May* 17–18, 1901. **H. W. Smith.** (Astrophys. Journ. 15. pp. 199–207, April, 1902.)—In this paper the author gives a preliminary account of the photographic work undertaken by the expedition from the Massachusetts Institute of Technology to Sawah Loento, in Sumatra. Four lenses were employed for obtaining pictures of the corona and of the surrounding regions of the sky in search of intra-mercurial planets. One of the corona cameras was provided with isochromatic plates and a colour-screen. All four cameras were mounted on a wooden framework rigidly attached to a steel polar axis, which was driven by an electric motor ingeniously controlled from a pendulum adjustable for rate. [See preceding Abstract.] A portable storage battery of six *five-ampere* cells was found sufficient to drive the motor. Several of the plates were spoilt by the clouds, but two excellent negatives were obtained, one exposed for half a second and showing the prominences at second contact, the other a long exposure of 20 seconds for coronal extensions. The coronal disturbance described by other observers is well shown on both negatives. The polar streamers extend nearly one-half diameter from the moon's limb, and the equatorial streamers on the west fully one diameter. A noticeable feature was that, notwithstanding the long duration of totality, the darkness was never such as to render a lamp necessary. Attempts were made to photograph the shadow bands directly, but their ill-defined appearance was sufficient to explain the negative results. C. P. B.

1825. *Stellar Scintillation.* **E. von Oppolzer.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 1239–1252, Dec., 1901.)—The author considers

Montigny's problem, to determine the separation of two rays of different refrangibilities, both coming from the same star, and both arriving at the same point. He sets out from the formula for a medium composed of homogeneous spherical shells, $\mu r \sin i = \text{constant} = \mu_0 a \sin z$; here μ is the index of refraction at distance r from the earth's centre, i the inclination of the ray to the radius r, μ_0 the index at the earth's surface, a the earth's radius, and z the apparent zenith distance of the ray. For the linear separation at the limit of the atmosphere of two rays whose indices of refraction differ at the earth's surface by $\delta\mu_0$ he finds—

$$\Sigma = a\,\delta\mu_0 . \sin z \left\{1 - R_0\mu_0 \cot z/(\mu_0 - 1)\right\},$$

R_0 denoting the "refraction" at the place of observation (defined by $z = z_0 - R_0$, where z_0 is the true zenith distance. This result differs both from that of Montigny and that of Rayleigh (Phil. Mag. 5. 36. p. 129). It applies only to rays meeting at sea-level; the requisite modifications for other cases are given. W. S.

1826. *Brightness of Star-Clusters.* **J. Holetschek.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 1253–1297, Dec., 1901.)—The author compares the observed brightness of a large number of clusters with that calculated from the brightnesses of the individual stars. He finds that the brightness of the cluster is given, to a very close degree of approximation, by that calculated from a comparatively small number of the brighter stars; generally it is sufficient to take the stars of the two lowest magnitudes in the cluster. A large number of numerical instances are given. W. S.

1827. *Analytical Discussion of Algol Variables.* **A. W. Roberts.** (Roy. Soc. Edinburgh, Proc. 24. pp. 71–84, May, 1902.)—An examination is made of the general principles of Algol variation, in which the character, extent, and duration of the mutual eclipses in any dual stellar system depend on the elements of the orbit, and on the relative size and brightness of the component stars. The latter being known, we can calculate what the amount of eclipse will be, but in general practice the problem is the converse of this, the elements of the orbit having to be determined from the observed light curve. After deriving the formulæ necessary, they are applied to the variable of this type recently discovered at the Cape Observatory—C.P.D. — 41·4511°. The period is 44h. 30m., and the variation in brightness is confined to 4h. 30m. The orbit of the system is inclined 5° 43′ to the plane of sight; both components are about equal in size but not in brightness, one being about six times as bright as the other. The two stars are separated from one another by a distance equal to twice the diameter of either. The mean density of the system is about half that of the sun, or two-thirds that of water. C. P. B.

REFERENCES.

1828. *Gravity Measurement.* **L. Haasemann.** (Zeitschr. Instrumentenk. 22. pp. 97–103, April, 1902.)—This is a description, with discussion, of pendulum apparatus, with chronometer, for the German South Polar Expedition. A. D.

1829. *Maximum Moments and Wheel Loads.* (Railroad Gazette, 34. pp. 373–374, May 23, 1902.)—Several problems on beams with a distributed dead load and a system of concentrated travelling loads are worked out. H. R. C.

LIGHT.

1830. *Reflection and Transmission of Light by Metal Conducting a Current.* **P. V. Bevan.** (Cambridge Phil. Soc., Proc. 11. pp. 380–390, May, 1902.)—The effect of the current in the metal is to cause an alteration in the constants of the metal, but this alteration is too small for the effects to be measurable (taking 10^{-2} of a wave-length as the minimum change of phase which can be detected.) The alteration also of the plane of polarisation (or rather of the major axis of the ellipse of polarisation) of reflected light is similarly too small to be detected. The thickness of metal through which light can be passed being only a few wave-lengths, there is no possibility of the small difference of velocity producing a large enough change of phase to admit of measurement. A. D.

1831. *Index of Refraction of Liquid Mixtures.* **E. van Aubel.** (Comptes Rendus, 134. pp. 985–987, April 28, 1902.)—A. Leduc finds [see Abstract No. 1510 (1902)] that the refractive energy of the components is conserved in the mixture of two liquids; and verifies this in a mixture of alcohol and water which presents the maximum index of refraction. The law is, however, by no means a general one; the refractive energy is generally not conserved. A. D.

1832. *Indices of Refraction of Solutions of Sodium Chloride.* **C. Bender.** (Ann. d. Physik, 8. 1. pp. 109–122, April 29, 1902.)—Values are given of the indices of refraction of sodium chloride solution of the following strengths: N/5 N, 2N, 3N, 4N and 4·5N for the rays H_α, D, H_β and H_γ. The methods of experiment have already been described [see Abstract No. 1413 (1900)] and the temperature limits were 10° to 70°. From the values given, the following numbers were calculated, the light being that of the D line: Molecular refraction of NaCl at 15°, 9·273; Index of refraction of solid NaCl at 15°, 1·5985; Atomic refraction of sodium at 15°, 3·493; Index of refraction of metallic sodium at 15°, 1·23601. E. C. C. B.

1833. *The Observation of Conical Refraction.* **C. Raveau.** (Soc. Franc. Phys., Séances, 3. pp. 226–229, 1901.)—It is usual in discussing the singularities of Fresnel's wave-surface to consider only such geometrical abstractions as single rays and ray-cones. The author endeavours to extend the theory to the study of small pencils, with which we are always concerned in practice. Suppose a small incident pencil of rays in the region of the optic axis to converge to a point S on the face of a doubly refracting crystal plate with parallel faces. A certain ray, AS of this pencil, will on entering the crystal be divided, not into two rays, but into a cone of rays, and the emergent beam will be a cylinder of the second degree C. Further, every ray lying on a certain cone of the incident pencil will have one of its emerging components on a cone Γ, whose vertex is on the second face of the crystal and inside C. The other rays of the incident pencil, supposed to have the form of a cone about AS, will emerge around the cylinder C, and may then be regarded as making up a system of elementary pencils, each having for axis a generator of C. One focus of such a pencil is at infinity, where the generator meets its

neighbour. In finding the other focus, the emergent rays are considered as lying in planes normal to the cylinder along a generator, the focus being the point where a generator meets a ray lying in such a plane. The two rays due to the doubling of any incident ray IS lie in the two normal planes of the cylinder parallel to SAI. It is to be noted that the two caustic-surfaces for the ordinary and extraordinary pencils merge into one in the region under discussion, where we pass continuously from one sheet of the wave-surface to the other. The caustic is a surface of two sheets, and, in view of the small inclination between the generators of the cone and cylinder, one sheet must be tangential to Γ and C near one of their curves of intersection. Further consideration shows that the required focus lies near the curve of intersection of C with the sheet of the cone opening towards the point S. In the usual arrangement for showing the existence of conical refraction, an illuminated hole is projected across a crystal plate by means of a lens, and a bright ring is obtained on a screen, which is the image of the curve of contact of C with the caustic. On widening the illuminating pencil, the ring will be found to gain in brightness without losing much in sharpness. The second sheet of the caustic has a singular form, it is asymptotic to C, and has a conical point at the vertex of Γ. Except at infinity, it reduces sensibly to a line. A corresponding white spot may be found by shifting the screen, and serves to show when the plate is properly oriented. The spot disappears in the region of the focal plane of the projecting lens. A. E.

1834. *Focus of an Oblique Pencil refracted at a Spherical Surface. A Simple Proof of Young's Formula.* **A. Champigny.** (Soc. Franc. Phys., Séances, 3. pp. 220–222, 1901.)—Let A be the source, B the (primary) focus, C the centre of curvature, O the point of incidence, AO = a, BO = b, angle OCA = 0, and angle OAC = α. Then $i = o + \alpha$ and $da = di - do$, also $di \cos i = ndr \cos r$. If O′ be a point near O, we have from the triangle AOO′, AO′ : sin O :: OO′ : sin da, or $a/\cos i = \rho do/da = \rho do/(di - do)$, or $do(\rho \cos i + a) = adi$. Similarly from the triangle BOO′, $do(\rho \cos r + b) = bdr$, and by division—

$$\frac{\rho \cos i + a}{\rho \cos r + b} = \frac{n \cos r}{\cos i} \cdot \frac{a}{b}.$$

A. E.

1835. *Images of a Point by Refraction at a Spherical Surface.* **A. Cornu.** (Soc. Franc. Phys., Séances, 3. pp. 222–226, 1901.)—The construction for the focus of a pencil of rays in the plane of incidence depends on the following theorem [stated by Young (see Phil. Trans. 1801, xcii. p. 28), but rediscovered by Cornu] : Let A be a luminous point in the plane of a refracting curve OM ; AO, OB an incident and refracted ray, B the point on the caustic corresponding to A. Then as A moves along the incident ray, the line AB always passes through a fixed point J. The point J, called the centre of junction, is the foot of the perpendicular let fall from C the centre of curvature at O, upon the line joining the feet of the perpendiculars from C on AO, OB. The theorem follows at once from the well-known formula $(\cos i - n \cos r)/\rho = \cos^2 i/a - n \cos^2 r/b$, where a = OA, b = OB, and ρ is the radius of curvature. For the equation of the line AB referred to oblique axes OA′, OB will be $x/a + y/b = 1$, and since the above formula expresses a linear relation between the reciprocals of a and b, the line passes through a fixed point. The co-ordinates of this point, $x = -\rho \sin r \cos^2 i/\sin(i = r)$; $y = +\rho \sin i, \cos^2 r/\sin(i - r)$, will be found to satisfy the conditions stated above. The image of the point A is, of course, astigmatic, being composed of two linear elements. One element (primary

focus) is perpendicular to the plane of incidence at B, the other (secondary focus) lies in the plane of incidence along AC, where AC cuts the refracted rays. Thus for the secondary focus, C takes the place of J. A. E.

1836. *Improved Michelson Interferometer.* **H. C. Pocklington.** (Cambridge Phil. Soc., Proc. 11. pp. 375–379, May, 1902.)—In the modified arrangement, the two interfering beams consist of circularly polarised light, and a retardation of either causes rotation of plane of polarisation of the resultant. The incident light employed is plane polarised. A plate of mica producing a retardation of $\frac{1}{8}$ wave is inserted in the path of one beam, and a similar plate in the path of the other beam. As each plate is traversed both in going and returning, each beam has $\frac{1}{4}$ wave retardation of one of its two component vibrations compared with the other, and is thus circularly polarised. The polarisations of the two beams are opposite, and the resulting plane polarised beam is examined by a nicol. When the nicol is rotated, the interference bands move across the field. It is claimed that the accuracy of an observation is nearly two hundredfold greater than in the ordinary method. An alternative method, suggested by Laurent's Polaristrobometer, and not involving the use of circularly polarised light, is described in a Note of later date. The mirrors are to be adjusted so as to give an even shade; and then half of one mirror is to be covered with a thin plate which causes a small retardation (or a plate may be cut in two and one half slightly tilted). If now the whole of the light be retarded by a further accurately measurable amount (by interposing a moderately thin plate which can be inclined), the two halves of the field will become dark in rapid succession as the analyser is rotated. A very small rotation of the analyser has a large effect, giving great sensitiveness. A. E.

1837. *Focal Lines and Anchor-ring Wave-fronts.* **J. D. Everett.** (Phil. Mag. 3. pp. 483–486, May, 1902. Paper read before the Physical Society.)—The case here described is that in which the wave-front in one of its positions is a tore or anchor-ring. All the rays, even of a large pencil, incident obliquely on a spherical reflecting or refracting surface, in this case pass through two definite focal lines. Of these, one is a circular arc cutting the pencil at right angles, and the other is a straight line, which may have any inclination to the axis of the pencil. This is shown mathematically, and experimental illustrations are given. J. W. P.

1838. *Negative Images due to Certain Vapours.* **P. Vignon.** (Comptes Rendus, 134. pp. 902–904, April 21, 1902.)—Colson and Russell have investigated the emanations from a fresh surface of zinc, capable of fogging a photographic plate or making an image of scratches on the zinc. The author has made negatives of medallions in plaster dusted with powdered zinc, and so forth; the reliefs make more impression than the hollows, being nearer to the plate. The scale of relief is very well brought out, but the hollows are blurred, not being in contact: the contrasts are increased. Ammoniacal vapour acting upon linen impregnated with a mixture of powdered aloes and olive oil also makes brown negative images. A. D.

1839. *Stereoscopic Radiography.* **T. Guilloz.** (Comptes Rendus, 134. pp. 756–758, April 1, 1902.)—Images are formed in rapid alternation, one for each eye, by means of apparatus which is described, while the other eye is masked off. If the frequency of alternation be sufficient, the impression on each eye is continuous, and the combined effect is that of stereoscopic relief. A. D.

1840. *The Retina.* **C. Maltézos.** (Journ. de Physique, 1. pp. 228–233, April, 1902.)—The eye fatigued by light, comes sooner to its normal state when directed towards green colour of moderate luminosity. This is not easy to explain on Young's, but is readily explained on Hering's theory. The minimum visible luminosity, which is smaller as we go towards the periphery from the *fovea centralis*, seems to undergo an oscillation in its value. In darkness, the result of concentrated attention (central action in the optic nerve) is an irregular very feeble stimulation, particularly in the region of cones. Concentrated attention, upon a bright light looked at, much reduces the after-effects of fatigue : there may even be no after-image at all, while the same flame casually in view but not looked at may induce a powerful after-image. The cerebral activity thus increases the restitutive power of the optic nerve (the absence of attention thus explaining amblyopia by anopsis, the blindness of an unused eye). Light falling on the retina induces—(1) bleaching of the retina-purple (which is regenerated in darkness) ; (2) transport of pigment from the pigmentary cells so as to construct the section of the rods and cones ; (3) swelling of the ends of the rods and cones ; (4) probably, torsions of the rods and cones. The rods and cones have to send back the pigmentary matter brought between them during the action of light ; if they fail to do this we have the pigmentary degeneration of the retina. The pigmentary epithelium seems therefore to act as a kind of brake put upon the too energetic movements of the rods and cones ; but the case of albinos shows that it is not indispensable to vision. A. D.

1841. *Zeeman Effect on Series Lines.* **C. Runge** and **F. Paschen.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 19. pp. 380–386, April 10, 1902. Also Astrophys. Journ. 15. pp. 333–339, June, 1902.) –Preston observed that lines of different elements, which correspond to one another according to the series law, are decomposed in the magnetic field in such a way that on a scale of vibration numbers the components of corresponding lines in equal magnetic fields stand at equal distances. The authors have verified this with great care for Hg, Mg, Zn, Cd, Sr. When the lines are normal triplets it follows from H. A. Lorentz's laws, that in the spectra of the different elements the relation of the charge to the mass of each particle is the same : and it would seem as if in the different spectra we had to do with identical particles with an intermolecular material corresponding to the respective elements. In the spectra of different elements similar charged particles oscillate round their centres of gravity while the chemical molecules only determine the forces with which the particles are, in the absence of a magnetic field, drawn into the position of equilibrium. The spectrum is therefore different for each element ; but the decomposition of corresponding lines in a magnetic field is equal in different spectra. A. D.

1842. *Magnetic Rotation of the Polarisation Plane in an Absorption Band.* **P. Zeeman.** (Konink. Akad. Wetensch. Amsterdam, Versl. 11. pp. 6–12, May 31, 1902.—A result of Voigt's theory relative to the rotation of the polarisation plane in an absorption band seemed to be contradicted by Corbino's recent researches [see Abstract No. 36 (1902)] ; in fact, instead of a negative rotation in the interior of an absorption band, as required by this theory, he obtained a small positive rotation only. The author therefore tests this question by new experiments, observing the alterations shown by the interference bands produced by a Fresnel prism system in the neighbourhood of the sodium lines, as the amount of sodium vapour present in the magnetic

field is gradually increased, the latter being kept constant. In a field of 18,000 units, a displacement equivalent to more than twice the distance of two bands, corresponding to a negative rotation of approximately 400° was observed in the case of D_1, the distance of the poles being 4 mm. With D_2 the phenomena noted were of a similar character. Increasing the magnetic field will produce a diminution of this negative rotation. For very high vapour densities, however, phenomena identical with those recorded by Corbino were noted. The author maintains that this behaviour is not in disagreement with the theory; further experimental work, however, will be necessary to account for the whole of the phenomena observed. A. G.

1843. *Rotatory Magnetic Dispersion within Absorption Lines.* **W. Voigt.** (Accad. Lincei, Atti, 11. pp. 459–462, May 31, 1902.)—Corbino's results [see Abstracts Nos. 36, 1515 (1902): Voigt, Abstract No. 465 (1902)] do not involve any contradiction between theory and observation. They only show that certain complications were present, which have been dealt with by Zeeman (see preceding Abstract). A. D.

1844. *Magneto-Optics.* **Q. Majorana.** (Accad. Lincei, Atti, 11. pp. 374–376, May 4, 1902.)—On the analogy of Kerr's discovery (electrostatic lines of force inducing a certain anisotropism of a uniform medium, and therefore inducing birefringent power), the author sought for birefringence as the result of magnetic lines of force in a mobile magnetic medium. He found this to a slight extent in a solution of ferric chloride, and notably in some kinds of dialysed iron and ferric oxide in colloid solution; so that these converted plane into circularly polarised light. This birefringence could be compensated by glass subject to strain. Further, in solutions of ferric chloride which had been shaken up with oxide of iron, there is a rotation of the plane of polarisation when this plane was not parallel or normal to the lines of force, which rotation is independent of the direction of the field ("bimagnetic rotation") and is possibly due to the magnetic properties of the medium itself. Both these rotations are positive or negative according to the sample of liquid used; and the inquiry is complicated by the coexistence of more than one of these phenomena. A. D.

1845. *Action of Self-induction on the Spectra of Dissociation of Compounds.* **A. de Gramont.** (Comptes Rendus, 134. pp. 1048–1050, May 5, and pp. 1205–1207, May 26, 1902.)—The author describes experiments in which he has applied the results of Schuster and Hemsalech on the effect of self-induction in the sparking circuit upon the spectra of metals, to the analysis of the spectra of minerals and metallurgical products. [See Abstract No. 1066 (1900).] The introduction of self-induction into the circuit, weak at first and gradually increasing, procures simplification of the spectra of dissociation, by eliminating first the air spectrum, then successively those of different metalloids: this may be advantageous in researches in analytical chemistry. His results confirm the conclusions of Hemsalech and the classification of rays founded by that experimenter on his study of the metals. W. C. H.

1846. *Lamps for Spectroscopic Analysis. IV.* **E. Beckmann.** (Zeitschr. Phys. Chem. 40. pp. 465–474, April 15, 1902. Communicated by the Laboratory for Applied Chemistry in the University of Leipzig.)—This is a continuation of papers already published by the author. [See Abstracts Nos. 2419 (1900) and 1491 (1901).] He here gives methods by which solutions may be

converted into spray for spectroscopic purposes, and describes a modification of the glass apparatus used by Ebert and others. This modification consists in constructing the nozzle of ebonite, and allows the apparatus to be more accurately made and adjusted. A rod of ebonite has a passage made through a portion of its length, connecting by a lateral opening with the fluid to be sprayed. Another passage introduces air under pressure, the two passages terminating immediately beneath an ebonite cap or nozzle. A further method of spraying solutions is a modification of the device originally described by Lockyer. Air under pressure is led over the top of a tube connected to a vessel containing the liquid, the whole being contained in a cylindrical glass chamber, which has a tube connected to it on the top side. In this way the air charged with liquid particles in a fine state of division escapes by the top tube. This method is considered to be the most suitable for ordinary chemical work. W. H. S.

1847. *Spectrum Arrangement for Microphotometer.* **J. Koenigsberger.** (Zeitschr. Instrumentenk. 22. pp. 88–89, March, 1902.)—In a previous paper [see Abstract No. 1631 (1901)] the author described a microphotometer, and now suggests a small addition for spectrophotometric purposes. This consists simply in the insertion of a tube, containing a small direct-vision prism, between the analysor and the telescope; by reflection from the face of the prism the image of a scale in a side tube is thrown into the telescope so that the observer can see both the spectrum and the scale. For greater dispersion a second tube, containing two achromatic lenses placed the sum of their focal lengths apart, can be placed between the analysor and prism. Increased brightness and considerable accuracy is claimed for the apparatus. E. C. C. B.

1848. *Arc Spectra in Nitrogen, Hydrogen, and Ammonia.* **R. A. Porter.** (Astrophys. Journ. 15. pp. 274–281, May, 1902.)—Photographs were taken of the spectra of the arc in atmospheres of hydrogen, nitrogen, and ammonia, with iron, zinc, magnesium, and tin electrodes, and it was found that the effect of ammonia was approximately the sum of the effects of hydrogen and nitrogen as regards change of average intensity of the lines. Hydrogen reduces the average intensity very strikingly. Also, as a general rule, the spark lines are relatively reduced by nitrogen and enhanced by hydrogen. [Many of these facts, especially in connection with hydrogen, have been noted by Basquin.] [See Abstract No. 677 (1902).] E. C. C. B.

1849. *Ultraviolet Mercury Spectrum.* **H. Lehmann** and **R. Straubel.** (Ann. d. Physik, 7. 4. pp. 909–911, April 8, 1902.) The authors give a series of 27 lines in the ultraviolet region of the mercury spectrum between $\lambda = 2213$ and $\lambda = 1930$. The wave-lengths were obtained by comparison with the aluminium spark spectrum and two lines of Eden and Valenta's mercury spectrum. Kayser and Runge's formula does not apply to these lines below the limit of $\lambda = 2150$. This is, however, in accord with Schumann's observations of the ultraviolet spectrum of other elements. E. C. C. B.

1850. *Ultraviolet Spark Spectra of Elements.* **F. Exner** and **E. Haschek.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 964–987, 1901.)—This paper, which completes the list of the elementary ultraviolet spark spectra, contains those of thorium, arsenic, oxygen, nitrogen, chlorine, radium, and polonium, and in addition to these, the following elements were found in no way to give a spark

spectrum at atmospheric pressure: selenium, sulphur, phosphorus, bromine, and iodine. Hydrogen and fluorine were also experimented upon, but the well-known broadening of the lines, in the case of the former, prevented any measurements being taken, and, in the case of fluorine, only a faint continuous spectrum was seen, with curious bright maxima. The wave-lengths of the lines are given at length, but there is much doubt about the lines attributed to polonium. The paper concludes with a lengthy discussion on the probable accuracy of the whole research, which is very high, and also contains an interesting diagram showing the relation between the number of spark spectrum lines given by the elements and their atomic weights. A curve is drawn showing periodical maxima and minima with a general tendency to increase with the higher atomic weights. [See also Abstract No. 676 (1902).]

E. C. C. B.

1851. *Ultraviolet Absorption of Solid Cyanine.* **A. Pflüger.** (Ann. d. Physik, 8. 1. pp. 230–232, April 29, 1902.)—In previous papers the author has noticed an absorption band in the ultraviolet region of the cyanine spectrum which is less intense than the one in the green. Wood, however, found this ultraviolet band to be very intense [see Abstract No. 2345 (1901)] which the author says was due to the use of common cyanine. A repetition of his old experiments confirms the author's original opinion. [See Abstract No. 1211 (1898).]

E. C. C. B.

1852. *Action of Light on Precious Stones.* **Chaumet.** (Comptes Rendus, 134. pp. 1139–1140, May 20, 1902.)—The fluorescence excited in the diamond by violet light is well known. The author finds that this is intimately related to the brilliancy displayed by the diamond in artificial light, especially candle-light. The most brilliant stones are not the most regularly cut, but those which are most clearly fluorescent when subjected to violet light; they exhibit a clear blue, very luminous fluorescence, while less brilliant diamonds simply assume a violet colour. A brilliant yellow diamond with a large number of facets, when subjected to the action of violet light for a few minutes, shone vivid red, and its colour afterwards had changed from yellow to dull brown, the stone thereby losing four-fifths of its commercial value; it recovered its colour and brilliancy in twenty-four hours. The action of violet light also distinguishes the rubies of Siam from the greatly inferior rubies of Burmah. Those of Siam exhibit a scarcely appreciable fluorescence, while the Burmese stones are invariably very fluorescent and gleam brilliant red.

W. S.

1853. *Radio-activity of Thorium.* **E. Rutherford** and **F. Soddy.** (Chem. Soc., Journ. 81. and 82. pp. 321–350, April, and pp. 837–860, July, 1902.)—After an historical *résumé* of present knowledge as to radio-activity, the authors state the scope of their own work, which has for its object the investigation of the radio-active emanation from thorium, though incidentally the ordinary emanation is also examined. The methods employed are electrical, and depend on the fact that the radiation in question possesses the power of discharging both positive and negative electricity. These methods are capable of great refinement and certainty. The questions proposed for answer by the experiments undertaken are the following:—1. Is the power of producing an emanation a specific property of thorium, or is it due to a foreign substance which may be capable of separation from the thorium by chemical means? 2. Can the emanating power of "de-emanated" thoria

be regenerated by chemical means? 3. Does the emanation or radio-active gas itself possess any property which would associate it chemically with any known kind of gravitational matter? 4. Is it possible to detect by means of the balance any loss of weight corresponding to the continuous emission of the emanation, or any gain in weight of bodies rendered radio-active thereby? 5. Does the chemistry of thorium present any peculiarity capable of being connected with its almost unique power of producing an emanation? The present paper deals with the answers so far obtained to the first three questions. The emanating power and radio-activity were measured by observing the conducting power imparted to air as tested by a Kelvin quadrant electrometer of the White pattern. The rate of decay of the radiation from the emanation was observed. Thoria loses its emanating power to a large extent on intense ignition, but regains its power after a time. The cause of the emanating power appears to be only rendered inoperative for a period by ignition. Suggestions as to the nature of the emanation are considered. One of the inert constituents of the atmosphere may be rendered radio-active in the presence of thorium, or thorium compounds may emit a gas which constitutes the emanation. The latest experiments described give an account of the separation of thorium compounds into two portions, one possessing radio-active power in but a slight degree, the other possessing radio-active power in a degree many hundred times greater than that of ordinary thorium compounds. Substances chemically free from thorium have also been prepared possessing thorium radio-activity in an intense degree. It seems probable that, so far, the active constituent of thorium has only been obtained in relatively minute quantity, and therefore does not answer to any definite analytical reactions. J. J. S.

1854. *Absorption of Radio-activity by Liquids.* **T. Tommasina.** (Comptes Rendus, 134. pp. 900–902, April 21, 1902.)—The author describes his arrangement for studying the absorption of radio-activity by alcohol, benzene, petroleum, ammonia, glycerine, water, &c. A Curie electroscope is used, and the effect of the radiation from radium and barium chlorides, passing through layers of different thicknesses of the liquids is studied. A table of figures is given, showing the magnitude of the absorption for the different liquids. J. W. P.

1855. *Bactericidal Action of Light from Rapid-Oscillation High-tension Arc.* **H. Walsham.** (Röntgen Ray, Archives, 6. pp. 85–89, April, 1902.)—The bactericidal effects of the arc light are much superior to those of sunlight; the very rapid ultraviolet is absorbed by the atmosphere. A rapid oscillation high-tension arc, particularly between iron points, gives off an abundance of ultraviolet rays of extremely small wave-length, with a fair proportion of lower refrangibility; to these ultraviolet rays quartz is transparent, transmitting 60 per cent. through 4·4 mm., gelatine is quite opaque, ice is as transparent as air, and a film of iron oxide quite opaque. For use, as blood is opaque to the rays, they are passed through ice made to press upon the region affected, so as to make it anæmic. A. D.

REFERENCE.

1856. *Optical Measurements of Thickness.* **J. M. de Lépinay.** (Comptes Rendus, 134. pp. 898–900, April 21, 1902.)—A differential fringe method is described, which obviates the necessity of knowing the refractive index of the lamina to be measured. Practical description and results are to be communicated later. A. D.

HEAT.

1857. *Density and Expansibility of Ice.* **J. H. Vincent.** (Roy. Soc., Phi Trans. 198. pp. 463–481, May 13, 1902. Roy. Soc., Proc. 69. pp. 422–42 March 21, 1902 (Abstract).)—The water or ice under experiment was caugl below an umbrella-shaped vessel of steel immersed in mercury and attache to a scale-pan by a vertical steel wire passing through a small hole in th bottom of the funnel containing the mercury, so that its buoyancy coul be equilibrated and thus measured. Ten measurements were made on fou specimens of water at temperatures ranging from −10·02° to −0·37°. The seem to show that, as Nichols suggests, the same specimen of water ma assume different densities on freezing, seven observations giving 0·916212 a an average for the density of ice at 0°, while three give 0·915487. The autho concludes that 0·9160 may be taken as the density of ice at 0°, and that it cubical expansibility is 0·000152; he further thinks that the use of Bunsen ice calorimeter is limited in accuracy to $\frac{1}{10}$ per cent. owing to possibl differences in the character of the ice that results from the freezing of wate A useful and comprehensive *résumé* of the work done by previous observer is given. R. E. H

1858. *Heat of Solidification of Liquid Ammonia.* **de Forcrand** and **G. Massol.** (Comptes Rendus, 134. pp. 743–745, April 1, 1902.)—If the heat c solution at 10° of liquid NH_3 taken at −77° be calculated (1) from the specifi heat of liquid NH_3, its heat of volatilisation at −32·5°, the specific heat c NH_3 gas, and the heat of solution of NH_3 gas at 10°; (2) from the specifi heat of the liquid, and its heat of volatilisation at 10°, the values of 2·02 ca and 1,855 cal. are respectively obtained, in agreement with the value + 1·7 cal. previously found. [See Abstract No. 1328 (1902).] If the mean of th three results be added to the heat of solution of solid NH_3 at −77° in wate at 10° + 1·95 cal. is again obtained for the heat of solidification of 17 gr. c liquid NH_3 at −77°. The similarities between the properties of water an NH_3 are pointed out, and conformably to theory the difference (3·92 cal between their molecular heats of volatilisation at their boiling-points, and th difference (132·5°) between their boiling-points are such as to satisfy th equation 3920/132·5 = 30. W. E. T

1859. *Latent Heat of Ammonia.* **de Forcrand.** (Comptes Rendus, 13 pp. 768–770, April 7, 1902.)—The author obtains a confirmation of the valu + 7·695 cal., previously obtained for L + S for NH_3 [see Abstract No. 132 (1902)], by the direct determination of the values of L and S. S has bee determined as equal to + 1·95 cal. (see preceding Abstract), and by th application of Clapeyron's calculation to Regnault's determinations of th vapour pressure of liquid NH_3, L is now found to be + 5·73 cal.

W. E. T

1860. *Verification of Kirchhoff's Law for the Emission and Absorption o Glowing Tourmaline.* **A. Pflüger.** (Ann d. Physik, 7. 4. pp. 806–817 April 8, 1902.)—The only experimenters who have hitherto verified thi law directly are Bouman (who used heated glass and a radiomicrometer) an Rosenthal (who used heated quartz and mica and a spectrobolometri

method). The author uses plates of green tourmaline cut parallel to the axis and about 5 mm. thick. Then if I be the intensity of the source of light, T that of the transmitted, and R that of the reflected light, A the absorbed intensity, we have $A = I(1 - R - T)$. Then if Kirchhoff's law hold we must have (using the suffixes e and o to denote the extraordinary and ordinary rays) for the same temperature and wave-length $E_e/A_e = E_o/A_o$, or $E_e/E_o = A_e/A_o$, where E_e, E_o denote the components of the intensity emitted by the plate. The author measures E_e, E_o, T_e, T_o by a Lummer-Brodhun spectrophotometer, provided of course with a polarisation arrangement. R_e and R_o are calculated from the indices of refraction of the crystal. I_e and I_o are obtained by the spectrophotometer. The tourmaline is heated in a fishtail Bunsen flame. The source of light is a slit illuminated by an incandescent lamp. A lens casts a real image of the slit on the surface of the tourmaline plate, which can be adjusted to any required position. A real image of the first image and of the tourmaline plate is formed by a second lens in the plane of the collimator slit of the photometer. The Bunsen gives no radiation in the region used. The author shows that all assumptions and approximations used are justified. The results are given in the following table :—

No. of Experiment.	No. of Tourmaline Plate.	λ in $\mu\mu$.	$\frac{A_e}{A_o}$ (cold).	$\frac{A_e}{A_o}$	$\frac{E_e}{E_o}$	Percentage Difference.
1	1	635	—	0·580	0·578	0·04
2	2	635	0·470	0·650	0·641	1·2
3	2	610	—	0·488	0·492	0·8
4	3	635	0·375	0·600	0·589	1·8
5	3	610	—	0·439	0·438	0·02
6	3	635	—	0·590	0·594	0·7

W. S.

REFERENCES.

1861. *Specific Heat of Solutions, III.* **W. F. Magie.** (Phys. Rev. 14. pp. 193–203, April, 1902.)—This is in continuation of a former paper [see Abstract No. 2125 (1901)], and describes in detail the author's improved apparatus [see Abstract No. 76 (1900)] and his method of observation and correction. R. F. B.

1862. *Mutual Inter-distribution of the Elements of Two Swarms according to the Law of Chance.* **M. Thiesen.** (Deutsch. Phys. Gesell., Verh. 4. 6. pp. 98–105, March 21, 1902.)—The author holds Boltzmann's analysis to be bad, and gives his own solution of the problem, in which the non-continuity of the elements is especially considered. The Maxwell law then follows only on particular assumptions being made. R. E. B.

1863. *Self-regulating Thermostat.* **Tedeschi-Rosselli.** (Elettricità, Milan, 21. pp. 290–293, May 11, 1902.)—Descriptions are given, with drawings, of the Tedeschi-Rosselli self-regulating electric thermostat for bacteriological, embryological, and other purposes. A. D.

SOUND.

1864. *The Vowel "a."* **L. Bevier, Jr.** (Phys. Rev. 14. pp. 171–180, Mar and pp. 214–220, April, 1902.)—In a former article [see Abstract No. 1451 (190 the author published his results on the analysis of the vowel *a* (as in fathe He now considers the vowel *a* (as in hat). The method is to obtain the cu from a phonograph, then to measure ordinates and abscissæ (this by a mic scope) and so analyse, using the Fourier series, looking for harmonics up the tenth. In the case of the more simple curves, the eye can analyse t curve without mathematical aid. Results show that there are three resonan regions near frequencies 1550, 1050, 650, the first being by far the m important one. To explain, suppose the fundamental is 202, or 226, t reinforced harmonic will be 1616 or 1582 respectively. Whatever fundamen be sounded, the mouth cavity resonates the nearest harmonic to 1550. T same applies in less degree to the other resonance regions. But for very lo fundamentals, it is obvious that the harmonics lie close together, hence t mouth, being, not hard, but a soft, flabby resonator, responds to and amplifi more than one harmonic (sometimes even three) in the region of resonance

In the second part of the paper the author gives the analysis of the sou *e* (in pet). The method adopted is identical with that given in Abstra No 1451 (1900), on the sound *a* (in father). In this case the strong resonance is for frequency 1,800. There are two centres of weaker resonan at 1,050 and 620. Tables and curves are given. P. E.

1865. *Flutings in Sound-waves.* **S. R. Cook.** (Phil. Mag. 3. pp. 471–48 May, 1902. Paper read before the Denver meeting of the American Associ tion for the Advancement of Science.)—The question of the explanation acoustic attractions and repulsions by hydrodynamical considerations is he dealt with. Koenig supposed the perfect fluid to supply adequate explanatio but here the idea of viscosity is introduced. The perfect fluid contains forc which are essential, but not sufficient, to produce the flutings, and experiment it is found that there are other forces both parallel and perpe dicular to the stream lines. These additional forces are due to the viscosi of the medium. The case with which flutings may be formed depends up the size, shape, and specific gravity of the fluting material, and upon the mol cular weight, density, and viscosity of the medium. Experiments (modifi forms of the Kundt sound apparatus) are described with a variety of flutin materials (magnesium carbonate, lycopodium, cork dust, brass and ir filings, &c.), and with air, carbon-dioxide and chlorine as media. Sm spheres of sealing-wax of very perfect form were also used in the Kun tube, and their attractions and repulsions in the vibrating gas were studi microscopically. [See also Abstracts No. 2198 (1900) and 1094 (1901).] J. W.

1866. *Interference of Sound.* **Rayleigh.** (Nature, 66. pp. 42–44, May 1902. Royal Institution Discourse, Friday, Jan. 17, 1902.)—Experiments a described in which a "bird-call" was used as the source, and a high-pressu sensitive flame as the recipient. The construction of a suitable bird-call f laboratory and lecture experiments is described. The wave-lengths employ range from 1 to 3 cm., and thus many optical phenomena can be imitate Experiments illustrating ordinary interference, Huyghens' zones, Lloyd bands, Fresnel's bands, are described. Reference to fog signals and t use of elliptical horns is also made. [See Abstract No. 1337 (1902).] J. W.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

1867. *Motion of Ions in a Varying Magnetic Field.* **B. Davis.** (Science, 15. pp. 853–856, May 30, 1902.)—In some of the Crémieu experiments [see Abstracts Nos. 55, 56, and 482 (1902)] a disc was charged to a high potential, and suspended in the field of an electromagnet. When the current is broken, the disc should have experienced a force according to Maxwell's theory. The quantity of electricity that can be placed on a body of considerable dimensions is small, so that e/m is a small quantity. For a negative ion, this quantity is, however, very large, and therefore the ion should move with considerable velocity in a varying field of moderate strength. An anemometer possesses the property of rotating in one direction, whatever may be the direction of the particles acting on it. A special form of the instrument is placed at the centre of a large vessel which is surrounded by a large circular coil. An oscillatory discharge from a large battery of jars is sent through the coil, and, when the electrodeless discharge appears, a rotation is observed, sometimes in one direction and sometimes in another. Further experiments showed that some of these are due to radiometer effects, and after they are eliminated there still remains a definite rotation due to the motion of the ions. This is looked upon as definitely supporting Maxwell's theory. R. S. W.

1868. *Contact Difference of Potential.* **H. Pellat.** (International Physical Congress at Paris, Report, 4. pp. 77–83, 1900–1901.)—The author distinguishes between (1) the electromotive force of contact; (2) the true difference of potential; (3) the apparent difference of potential; (4) the difference of potential at contact according to Nernst's theory. (1) The quotient of the quantity of energy given to the current by the quantity of electricity which has passed, is determined from the Peltier effect in the case of two metals; (2) the quotient of the work done by the electric force acting on a charged particle passing from one place to the other by the quantity of electricity in the charge, has so far only been determined from electrocapillary phenomena; (3) is obtained from the study of condensers formed of the conductors in question; (4) is not to be *à priori* confounded with the true difference of potential. W. E. T.

1869. *E.M.F. due to Deformation of Electrodes.* **Hurmuzescu.** (Annal. Sci. de l'Univ. de Jassy, 2. pp. 63–64, April, 1902.)—Two electrodes, though of the same material, are rarely mechanically identical; the result is a small e.m.f. which may rise as high as some hundredths of a volt. If they be adjusted to reduce the electrometer to zero, traction upon one of the electrodes will make that electrode negative, and the more so the softer the metal is. Under magnetisation an electrode becomes more positive. It is as if traction laid the molecules more open to attack by acid, and magnetisation packed them closer together. A. D.

1870. *Electrostatic Rotations.* **G. Vicentini.** (N. Cimento, 3. pp. 296–306, April, 1902.)—References are given to Quincke (Wied. Ann. 59, 417, 1896), Heydweiller (Beibl. Wied. Ann. 21, 529, 1897), Boltzmann (W. A. 60, 399,

1897), Schweidler (Beibl. W. A. 22, 107, 1898), Heydweiller [see Abstr No. 102 (1900)]; Graetz [see Abstract No. 1280 (1900)]. The author l found rotations in liquid dielectrics; if quantities such as 3 litres be o set in rotation and a strong electric field set up between electrodes in dielectric, the velocity of rotation is surprisingly accelerated. Various oth movements are described; as a rule a maximum velocity is promptly obtain which gradually falls to a constant value, which depends upon the form the electrodes. Exploration of the potentials in the rotating liquid. Analog rotation in gases examined. A.

DISCHARGE AND OSCILLATIONS.

1871. *Self-Induction in Electric Discharges through Gases.* **B. Eginit** (Comptes Rendus, 134. pp. 1043–1046, May 5, 1902.)—The variation of t self-induction of the discharging circuit produces large variations in t heating effects at the poles between which the sparks pass. The temperatu of the poles increases enormously, showing maxima and minima as the s induction increases in value. This temperature depends also on the tempe ture of the poles before the sparks begin to pass. Experiments are describ showing that an iron core inserted in an induction coil in the sparking circ destroys the heating effect of self-induction. This destruction may be eitl total or partial, according to the value of the self-induction, the dimensi and nature of the core, and the nature, shape, and dimensions of the pol As the self-induction increases, the distance between the poles remaini constant, the temperature of the poles at first increases very rapidly. T difference of temperature between the poles, almost zero at the commen ment, becomes very large for small values of self-induction. The met showing large heating effects—iron, nickel, cobalt—are metals whose spec are intensified with increase of self-induction; those which do not show lar variations in heating are metals whose spectra are more or less diminished intensity, with increase of self-induction. The author does not agree w the opinion that the heating of the poles is due to the presence of metal vapour, or yet to the disintegration of the poles. W. C.

1872. *Action of an Intense Magnetic Field on the Anode Colun* **H. Pellat.** (Comptes Rendus, 134. pp. 1046–1048, May 5, 1902.)—The auth has already described the action of an intense magnetic field on the katho stream, and has shown how this action may be explained [see Abstracts N 323 and 1356 (1902)]. The present paper treats of the action upon the ano column. When the part of a Geissler tube which is well illuminated by ano rays is placed between the poles of an electromagnet, so that the magne lines of force are perpendicular to the rays, fields up to 425 c.g.s. un produce the well-known effect of deviation of the column and the formati of a luminous strip on the wall of the tube, becoming thinner and m intense as the field becomes stronger. But for field-strengths above 4 units, the luminous strip ceases to become thinner and increases more a more as the field increases, and for strengths of 7,000 to 8,000 units the anc column once more fills the whole section of the tube almost uniformly, b shows no stratifications. In this condition the resistance of the tube becon enormous, the equivalent spark in air reaching 24 mm. although it was o 1 mm. for no field or weak field. Other experiments show in a clear mann this great increase of resistance. On the other hand, if the magnetic lines force be in the same direction as the anode rays, there is no increase

resistance even for 7,000 to 8,000 units field strength. Thus the anode stream, like the kathode stream, experiences a very large mechanical resistance to its progress in a direction perpendicular to the lines of force of an intense magnetic field, but experiences a very much more feeble resistance to its progress in the direction of these lines of force. In the latter case, with the ends of the tube inserted into holes in the pole-pieces, the anode column becomes narrowed into a thin cylinder occupying only the axis of the tube, and this is perfectly explained by the result just given. The lines of force, leaving the walls of the holes in the pole-pieces, approach very close to one another between the poles, since the field is more intense there than in the holes. The anode stream takes exactly the shape of this tube of force on account of the difficulty it experiences in cutting the lines of force.

W. C. H.

1873. *Energy of Oscillating Discharge of Condenser in Vacuum-Tube.* **A. Maresca.** (N. Cimento, 3. pp. 337–352, May, 1902.)—In vacuum-tubes the energy expended in the form of heat is $H = A + B/R$ where A and B are constants, and R is the resistance of the discharging circuit. With rising potentials of discharge the energy is approximately proportional to the square of the potential. This applies (Kauffmann *contrà*, Energy $\propto V^3$) also to the case of ordinary gas-pressures. As the pressure falls, the energy expended in the tube increases, reaches a maximum and then diminishes. A. D.

1874. *Absorption of Electric Waves in Liquids.* **K. Wildermuth.** (Ann. d. Physik, 8. 1. pp. 212–226, April 29, 1902. Abstract from Tübingen Thesis.)—The oscillator consisted of two spheres immersed in oil, the waves from which passed along a pair of parallel wires. These in turn passed through a glass vessel containing the liquid under examination. The detector was a thermoelement of iron and constantan joined to a galvanometer. This method allowed the determination of the absorption coefficients for comparatively good and bad conducting liquids. Water, sodium chloride, and copper sulphide solutions behaved normally with waves of a period 21×10^{-10}, *i.e.*, their absorption coefficients are theoretically derivable from their conductivities. For waves of this period dilute ethyl alcohol showed an absorption directly proportional to the mass of absolute alcohol. Waves of a period 74×10^{-11} were more strongly absorbed by distilled water than would be expected from its conductivity. E. H. B.

1875. *Oscillatory Discharge of a Condenser.* **L. Mandelstam.** (Ann. d. Physik, 8. 1. pp. 123–148, April 29, 1902. Strassburg Thesis.)—An indirect method is adopted to determine the frequency of discharge. The oscillatory current is divided into two parallel paths, one containing an inductance, the other a non-inductive (electrolytic) resistance. Each path contains also one wire of a differential thermometer. Matters are adjusted so that the heating effects in the two wires are equal. The frequency is then calculated. In the actual experiments periods of the order $(2 \text{ to } 9) \times 10^{-7}$ second are dealt with.

E. H. B.

1876. *Interference Tubes for Electric Waves.* **A. Becker.** (Ann. d. Physik, 8. 1. pp. 22–62, April 29, 1902. Abstract from Heidelberg Thesis.)—Some of the more important results of this experimental work may be summarised as follows: 1. Using a two-branched Quincke's interference tube and a coherer as detector, the measured length of waves excited by various sources depends

only on the cross-section of the tubes, and is about 1·6 times the diameter the tube. 2. The Quincke's tube with two branches acts as a polaris allowing only those vibrations to pass which are parallel to its plane. vertically placed interference tube allows no waves to pass from an oscilla with horizontal axis. 3. By filling the stem of a T-shaped interference tu with an insulating liquid, the wave-length in it and hence its dielectric co stant may be determined. 4. The following determinations were made :—

Substance	Paraffin	Glass	Carbon disulphide	Alcohol	Wat
Dielectric Constant...	2·117	6·37	2·77	16·32	77 to

E. H.

1877. *Leakage of Electricity.* **H. Mache.** (Akad. Wiss. Wien, Sitz. B 110. 2a. pp. 1302–1306, Dec., 1901. Aus. dem. phys.-chem. Inst. der k. k. Univ. Wien).—This is a paper on the same lines as one by Elster and Geitel (Ph Zeitschr. 2. p. 116). Unlike those authors, Mache finds that the leaka is directly proportional to the potential of the charged body, other thin remaining the same. If the vessel is closed and the leak from the conduc in it is tested under the same conditions day after day, it is found gradually increase to about the fourteenth day, after which it remains constant. T leakage is found to be proportional to the pressure of the surrounding gas. rise in temperature from 16° to 60° is without influence. R. S.

1878. *Flower-like Distortion of Coronas due to Graded Cloudy Condensatio* **C. Barus.** (Amer. Journ. Sci. 13. pp. 309–312, April, 1902.)—The author h previously described the distortion caused by non-uniform distribution the nuclei in the production of coronas of cloudy condensation [see Abstra Nos. 691 and 1092 (1902)] ; he now works out the shape of the loci of li colour for non-uniform, but horizontally stratified, nucleation Flower-li curves are obtained of types repeatedly met with in working with volat liquids. He remarks that for benzol the nuclei do not originate in the liqu but are due to the diffusion of a horizontal conche of nuclei, broodi immediately over the surface of the liquid. W. E.

1879. *Rendering Visible the Damping of Electric Oscillations.* **J. Zenneck** (Ann. d. Physik, 7. 4. pp. 801–805, April 8, 1902.)—The author has shown [s Abstract No. 188 (1900)] how Braun's kathode-ray method may be modifi so as to give current curves on a fluorescent screen, which may be phot graphed. He here points out the suitability of the method for showing h the damping in a condenser circuit depends on inductance, resistance, dime sions, &c., and gives details of a suitable experimental arrangement. W.

1880. *Sounds at Electric Contacts.* **M. Hornemann.** (Ann. d. Phys 7. 4. pp. 862–881, April 8, 1902.) -In passing the current from an inducti coil through the human body there is often a sound (not to be confound with muscle-tone) produced at the contact of skin with electrode : t frequency coincides with that of the Wagner hammer of the small inducti coil. The sound is loudest when skin and electrode are dry, and the contact light, and when the skin is of a medium conductivity, not horny and damp. The electrode may be the skin of another person : the direction the current makes no difference. Weak induction currents favour the lo ness of the sound. With higher potentials a single electrode, acting unipola will produce the sound. The sound is due both to thermic effect and

electrostatic forces. With metal contacts in general neither of these causes operates: the interposition of a thin layer of an insulator does not develope sound; but that of a semi-conductor, such as graphite, does; coatings of oxide give variable results, but a thin coating of iron oxide mostly gives good results, even with unipolar oscillations acting through the contact. The contact acts as an indicator both of voltages and of currents. A. D.

1881. *Sounds during Discharges in Tubes or Flames.* **A. Righi.** (Accad. Lincei, Atti, 11. pp. 352–355, May 4, and pp. 457–459, May 31, 1902.)—A circuit contains a battery and 400 small accumulators, a sulphate-of-copper solution resistance R, a condenser, a telephone, and a milliamperemeter; and shunted across from the resistance to the milliamperemeter, a rarefied air-tube with adjustable aluminium electrodes, about $\frac{1}{2}$ cm. apart when the air in the tube is at a pressure of about 1 cm. First produce a tranquil luminous discharge between the electrodes; then close in the condenser branch circuit, and the discharge becomes intermittent, with production of a sound, audible in the telephone. The pitch of the sound increases on diminishing the resistance R, on increasing the number of accumulators in the battery, on diminishing the capacity of the condenser, on diminishing the distance between the electrodes in the tube, and on diminishing the pressure of air in the tube. The frequency of the intermittences may be reduced even to two or three per second, and may be so increased as to pass beyond audibility; but it is practically independent of the self-induction. The condenser is charged and discharged at every intermittence. A Bunsen flame will act like the tube if it be rendered conductive by NaCl vapour. The period of electric oscillations in the condenser circuit was always far less than that of the sonorous oscillations. When these two periods were made equal by increasing the self-induction of the condenser circuit, the phenomena come to resemble those of Duddell; the pitch of the sound becomes almost independent of the e.m.f. of the accumulators or of the resistance R. In intermediate conditions it was noticed that certain pitches of sound seemed possible, others not, so that there were sudden transitions from one pitch to another as the resistance or the self-induction was continuously varied; and in other cases the sound would not start spontaneously without the stimulus of a jar or of the movements of a tuning-fork. A. D.

1882. *Hall Effect in Gases at Low Pressures.* **H. A. Wilson.** (Cambridge Phil. Soc., Proc. 11. pp. 391–397, May, 1902.)—In uniform positive columns of hydrogen and oxygen at pressures below 1 mm. we have the Hall effect in hydrogen Z volts/cm. $= 2{\cdot}05 \times 19^{-2}\mathrm{H}/p$, p being the pressure in mm. Hg, and in oxygen $Z = 3{\cdot}79 \times 10^{-3}\mathrm{H}/p$. In air it is $2{\cdot}48 \times 10^{-3}\mathrm{H}/p$. The electric intensity X volts/cm. $= 28\sqrt{p}$ for hydrogen, $34{\cdot}9\sqrt{p}$ for air, $26{\cdot}9\sqrt{p}$ for oxygen. In a uniform part of the discharge $Z = \frac{1}{2}\mathrm{HX}(k_2 - k_1)$ where k_2 and k_1 are the velocities of the negative and positive ions respectively due to 1 volt/cm. Hence for hydrogen $k_2 - k_1 = 1{\cdot}47 \times 10^5 p^{-1{\cdot}5}$ cm./sec. For air it is $1{\cdot}42 \times 10^5 p^{-1{\cdot}5}$: for oxygen it is $2{\cdot}82 \times 10^4 p^{-1{\cdot}5}$. Along a discharge in air, the Hall effect and distribution of potential in the tube may be made nearly independent of the current. Then the variation of the Hall effect is very similar to that of the electric intensity. In a uniform part of the discharge, $Z = \frac{1}{2}\mathrm{HX}(k_2 - k_1)$, whence $Z \propto X$; but in the striated positive column, the Hall effect falls to an almost zero value between the striæ, whereas the electric intensity only falls to a comparatively small extent; whence $(k_2 - k_1)$ is very small in the dark spaces between the striæ. Probably the negative

electron torn off is at first very small and k_2 is relatively large ; but by the tin they have got into the dark spaces these negative electrons have becon attached to neutral molecules so that $(k_2 - k_1)$ is reduced. This view is agreement with the idea that each stria and its adjacent dark spa constitute a to some extent independent portion of the discharge analogo to that formed by the negative glow and Faraday dark space. [See al Abstract No. 1114 (1902).] A. I

1883. *Light Electric Effect.* **P. Lenard.** (Ann. d. Physik, 8. 1. pp. 14 198, April 29, 1902.)—This is a lengthy continuation of an earlier pap [see Abstract No. 1845 (1900)], on the various effects arising from th incidence of light of short wave-length on metal surfaces. The pap gives the results of experiments when the metal is in a vacuum, and when a vessel filled with gas. The quantity of electricity discharged is foun proportional to the light intensity, provided the quality remains the sam One of two plates U, E, is charged, and the influence of various conditio on the amount of electricity leaving U and reaching E is investigate It is found, *e.g.*, that a magnetic field normal to the plane of the plat is nearly without influence on the amount reaching E, but lessens th leaving U. An estimate is thus made of the tangential component of th velocity with which the charged ions leave the plate ; it is given a $1{\cdot}4 \times 10^8$ cm. sec The initial velocity of the ions is found independent the light intensity, but varies with the quality of the light. The position the plane of polarisation of the incident light is without influence. Whe the carriers of electricity which are released from the metal surface are sh into a space filled with gas, this is made conducting. R. S. W

1884. *Stationary Electric Waves.* **K. F. Lindman.** (Ann. d. Physi 7. 4. pp. 824–850, April 8, 1902.)—Electric waves are generated by a oscillator consisting of two short cylinders with rounded ends. Stationar waves are then produced by reflection from a mirror after the manner Hertz. Both in the experiments of Hertz and of the present author displac ments of the nodes and antinodes from their expected positions of a quarte wave-length apart are noticed. In the present work it is endeavoured t trace these displacements to a phase change at reflection. To investigat this matter the size of the mirror is varied from the order of the wave-lengt to much larger dimensions. Also as detectors of the waves are used :—(1) straight resonator with thermoelement ; (2) a circular resonator with therm element ; (3) a resonator with spark-gap. [See also Abstract No. 1317 (1901) E. H. B

1885. *Kathode-fall and Current-strength.* **J. Stark.** (Phys. Zeitsch 3. pp. 274–275, April 1, 1902.)—The normal kathode-fall is independent of ga pressure and current-strength ; but there is some variance as to the abnorma G. C. Schmidt (Ann. d. Phys. 1. 640, 1900) makes it a linear function of th current-strength. So does C. A. Skinner [see Abstract No. 487 (1902)]. Th author finds clearly, however, that their observations were made between to narrow or between unsuitable limits, and that the function is not linea Hittorf was right in 1884 (Wied. Ann. 21, 129, 1884) in plotting curved lines A. I

1886. *Electric Oscillations.* **G. Morera.** (N. Cimento, 3. pp. 382–38 May, 1902.)—In the case of a filiform conductor connecting two charge

conductors, Kelvin's formula implies that the two conductors form a perfect condenser, and is not applicable to Hertz's oscillator. In general, if the two conductors have the charge $-\Gamma$ induced in either when put to earth under the influence of the other charged to unit potential (in the case of condensers this is the electric capacity), and if $\gamma_1\gamma_2$ be their respective charges at unit potential, and if R be the resistance and L the self-induction of the wire connecting these two conductors; then the discharge will be oscillatory when—

$$\sqrt[2]{\frac{(\gamma_1+\gamma_2)L}{\Gamma(\gamma_1+\gamma_2)+\gamma_1\gamma_2}} > R;$$

and the period of oscillation will be—

$$T = \frac{2\pi}{\sqrt{\frac{\gamma_1+\gamma_2}{\Gamma(\gamma_1+\gamma_2)+\gamma_1\gamma_2}\cdot\frac{1}{L}-\frac{R^2}{4L^2}}}$$

A. D.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1887. *Electric Conductivity in Glowing Electrolytic Bodies.* **E. Bose.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 1. pp. 1–19, 1902.)—This is an investigation of how the current is conveyed in the Nernst incandescent lamp. Marked differences are found, according as a continuous or alternating current is used, and this is proved to be due to electrolytic action. R. S. W.

1888. *Resistance of Selenium at Low Temperatures.* **A. Pochettino.** (Accad. Lincei, Atti, 11. pp. 286–289, April 6, 1902.)—Where the resistance of a selenium cell falls under the impact of light from 31,000 to 18,000 ohms at ordinary temperatures, the resistance of the same cell at the temperature of boiling liquid air falls from 2,600 to 1,900 ohms. This tells against the photo-electric effect (0·4 in the former, 0·3 in the latter case) being due to chemical reactions, say between selenium and metal, which reactions are absent in the latter case. A. D.

1889. *Large Influence Machine.* **O. Brooks.** (Journal of Electricity, S.F. 12. pp. 87–88, May, 1902.)—Description is given of a large double influence machine in which there is a double row of neutralising pins to secure a more perfect discharge of the plate surfaces after passing the collecting combs, and in which the inductor field plates on one side are metallically connected with the collecting combs. This last feature is unorthodox, but it seems to increase the reliability very much, and to prevent reversal of polarity. A. D.

ALTERNATING CURRENTS AND MAGNETISM.

1890. *Oscillatory Charging Currents.* **H. Andriessen.** (Ann. d. Physik, 7. 4. pp. 912–918, April 8, 1902.)—In these experiments the usual practice is reversed, and a study made of the oscillatory currents that may occur in charging a condenser with a spark-gap in circuit. It is found that condensers allow a much greater current to pass than would be inferred from the voltage, capacity, and frequency used. The ramified sparks seen on the Rosetti plate and the phenomena termed side-discharges are held to be the cause of oscillatory charging currents. Air insulation at high voltages is disadvantageous because oscillatory sparks occur there. The superiority of oil insulation lies partly in its avoidance of such sparks. [See also Abstract No. 1367 (1902).] E. H. B.

1891. *The Electrometer in Alternate Current Measurements.* **K. Hohag** (Elektrotechn. Zeitschr. 23. p. 365, April 24, 1902.)—The electrometer is use in conjunction with a small 2-pole alternator mounted on the main alternat shaft, and having its field magnets arranged so that they are capable of bein displaced through a known angle about the armature shaft. The armature this little auxiliary machine is wound with a large number of turns of fi wire, and developes a fairly high e.m.f. It is evident that by displacing t field magnets the phase of the auxiliary e.m.f. may be varied at will while i magnitude remains constant. This auxiliary e.m.f. of variable phase is intr duced between the needle of the electrometer and one pair of quadrant The arrangement may now be used for measuring an alternating current an its load and idle components by the following method : Included in the mai circuit of the generator is a small resistance r (not necessarily non-inductive whose terminals are connected to the two pairs of quadrants of the electr meter arranged as described above. If the generator is first loaded no inductively, and the field magnet of the auxiliary alternator rotated until maximum deflection is obtained, then the field-magnet position will corr spond to a co-phasal relation of the auxiliary e.m.f. and the p.d. across r, an the maximum electrometer deflection will be proportional to the curren Let now the load be an inductive one; then in order to obtain a maximu deflection the field magnet of the auxiliary machine must be rotated from i standard position (found as described) through an angle θ equal to the phas difference between the p.d. and current in the main circuit. The maximu deflection is proportional to the total current; the deflection in the standa position, to the load current; and that in a position at right angles to t standard one, to the idle current. A. F

1892. *Magnetism Induced by Rapidly Oscillating Currents.* **W. M Varley.** (Phil. Mag. 3. pp. 500–512, May, 1902.)—The object is to fi how the magnetisation depends on the strength and frequency of t currents and on the diameters of the iron wires used. Frequency depen on the product L.C. (inductance and capacity), whereas the maximu current depends on the ratio C/L. Hence, if care be taken to mainta the product constant, the dependence of the magnetisation on the fiel strength alone can be found; but if the ratio is maintained constan the dependence of the magnetisation on the frequency alone is foun Both the maximum current and the magnetisation produced were measur by Braun's method of using the deflection of kathode rays. An oscillati current was produced by discharging Leyden jars through a micromet spark-gap, and various coils. The values of the inductances were eith calculated or found experimentally. The results show that (1) magnetis tion increases as the magnetising current increases; (2) magnetisatio decreases as the frequency increases; (3) magnetisation, for the most rap frequencies, is proportional to the surface of the iron, except for t thinnest wires. This shows that, for these frequencies (about 130,000 p sec.), the magnetisation only penetrates to the centre of the wire in t case of the thinnest wire used. P. E.

1893. *Magnetism and Thermal Conductivity of Iron.* **D. Korda.** (So Franc. Phys., Séances, 3. pp. 288–292, 1901.)—In Abstract No. 1041 (189 will be found a description of the method used by the author to show th conductivity decreases along the lines of magnetic force and remai unaffected across those lines. In the present paper, besides the abov method, he describes experiments on rods of iron, the same result bei found. P. E.

1894. *Null Method for Magnetic Measurements.* **R. Goldschmidt.** (Elektrotechn. Zeitschr. 23. pp. 314–315, April 10, 1902.)—Suppose two bars have to be compared as to their permeability. A primary coil is wound round each in series. A secondary coil is also wound round each in series, but the turns are so adjusted that when current starts in the primary there is no current in the secondary as measured in a millivoltmeter. In that case a simple proportion exists between the lines of force in the two bars and the turns in their respective secondary coils.

This simple method has been used in many ways, *e.g.* (1) for bars, (2) for dynamo pole-pieces, (3) for investigating the actual increase in magnetic resistance in an iron ring which has a thin air-gap in it. P. E. S.

1895. *Distance between the Poles of a Magnet.* **C. Benedicks.** (Journ. de Physique, 1. pp. 302–307, May, 1902.)—In a bar magnet it is easy to find the magnetic moment and the strength of each pole (by a coil for induction at the centre of the bar) and hence the distance between poles can be determined. The ratio l/L, where l = distance between poles and L = length of magnet, is not approximately constant ($= \frac{5}{6}$), as Kohlrausch found; on the contrary, the ratio steadily increases to a limit as the magnetising field increases. The curve for l/L, as H varies, is the inverse of the curve for susceptibility and H. P. E. S.

ELECTROPHYSIOLOGY AND ELECTROTHERAPEUTICS.

1896. *Electric Properties of Nerves.* **V. Grandis.** (Accad. Sci. Torino, Atti, 37. 10a. pp. 215–220, 1901–1902.)—The results previously obtained by the author [see Abstract No. 2181 (1901)], and attributed by him to magnetic lines of force, he now attributes to electrostatic induction. Charging a nerve negatively, whether by conduction or by induction, causes excitation; charging positively has no such effect. Galvani discovered this, but it had been forgotten. Every variation in negative charge induces muscular contraction. Nerve seems to be rather a dielectric than a conductor; different points of it can be at different potentials, there can be oscillations of potential values in it, and it has a resistance of 7,000 ohms per cm. A. D.

REFERENCES.

1897. *Potential Measurement.* **F. Henning.** (Ann. d. Physik, 7. 4. pp. 893–904, April 8, 1902.)—Apparatus is described for measuring air potentials with a flame, and a collector consisting of a radio-active substance, to render the air conductive. Quantitative comparative measurements are given. A. D.

1898. *Ionic Theory of Leakage of Electricity from Charged Bodies.* **J. Stark.** (Ann. d. Physik, 7. 4. pp. 919–931, April 8, 1902.) R. S. W.

1899. *Photographic Study of the Electric Discharge.* **K. Przibram.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 960–963, 1901.)—A continuation of an earlier paper. [See Abstract No. 2448 (1900).] R. S. W.

1900. *The First Layer of Kathode Light.* **E. Goldstein.** (Deutsch. Phys. Gesell., Verh. 4. 5. pp. 64–71, March 7, 1902.)—The paper contains an account of observations on the layer of light which comes between the Crookes' dark space and the surface of the kathode. [See also Abstract No. 707 (1902).] R. S. W.

1901. *Oscillations in Distributing Networks.* **Brillouin.** (Comptes Rendu 134. p. 768, April 7, 1902.)—Pomey's result [see Abstract No. 1713 (1902)] was show by the author in 1881, and previous to this by Helmholtz in 1851 in Ann. Phys. 7 pp. 513–514. A. D

1902. *Stationary Electric Waves on Wires by Condenser Discharges.* **F. Braun** (Ann. d. Physik, 8. 1. pp. 199–211, April 29, 1902.)—A discussion, descriptive an mathematical, of various arrangements for obtaining stationary waves along wires The paper is illustrated by nine figures. E. H. B

1903. *Walter's Röntgen-Ray Apparatus.* (Elect. Rev. 50. pp. 755–757, May 1902.)—This is a practical account of Walter's induction coil for use with th Wehnelt electrolytic break for Röntgen-ray tubes. [See Abstracts Nos. 38, 311, 172 (1899), 845 (1902).] A. D

1904. *Effect of Shape of E.M.F. Wave on Current.* **A. Russell.** (Elect. Rev 50. pp. 920–921, May 30, 1902.)—The author considers the following cases: (1) circuit containing resistance and inductance; (2) one containing resistance an capacity; (3) a circuit consisting of an inductive resistance in series with a capacity In each case an expression is obtained, in the form of a Fourier series, for th current due to an impressed e.m.f. represented by a Fourier series. A. H

1905. *Motion of Electrolytes in a Magnetic Field.* **O. Urbasch.** (Zeitsch Elektrochem. 8. pp. 150–153, March 6, 1902.)—The author replies to Drude [se Abstract No. 1113 (1902)], and reaffirms his former experimental results. [Se Abstract No. 107 (1901).] A. D

1906. *Motion of Electrolytes in a Magnetic Field.* **P. Drude.** (Zeitsch Elektrochem. 8. pp. 229–230, April 24, 1902.)—The author replies to Urbasch (se preceding Abstract) that with the same electromagnet and arrangement as used b Urbasch he obtains no such rotation. He thinks the motion observed must hav been the irregular surface-tension motions due to laying water upon concentrate sulphuric acid. A. D

1907. *Reports on Magnetic Observations made during the Total Solar Eclipse May*, 17–18, 1901. **W. Kesslitz,** Polar Magnetic Observatory, Austria; **T Moureaux,** Val-Joyeux Magnetic Observatory, France; **W. Haga,** Groninge University; **M. Snellen,** de Bilt Meteorological and Magnetic Observator Holland; **van Rijckevorsel,** Vlissingen, Holland; **C. Börgen,** Wilhelm haven Magnetic Observatory; **M. Eschenhagen,** Potsdam Magnetic Obse vatory; **H. A. D. Fraser,** Dehra Dún, India; **J. de Moidrey,** Zi-Ka-W Magnetic Observatory, China; **C. C. Farr,** Christchurch, New Zealand; **G. D Hosmer,** Sawah Loento, Sumatra; and **T. F. Claxton,** Royal Alfred Obse vatory, Mauritius Island. (Terrestrial Magnetism, 6. pp. 123–143, Oct.; and pp. 16 184, Dec., 1901.)

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1908. *Determination of Molecular Weight by the Boiling-point Method.* **E. Beckmann.** (Zeitschr. Phys. Chem. 40. pp. 129–157, March 25, 1902. Communication from the Laboratory for Applied Chemistry of the Leipzig University.)—The author gives a description of his original apparatus for the carrying out of this method, and also of the various modifications of it made by different investigators. A new apparatus is also depicted and described, the heating of the solution being effected by means of a current of the vapour of the solvent. A number of determinations of the molecular weights of different substances show that the new apparatus yields very accurate results. Comparison is made between the two methods of boiling the solution—by direct heating, and by means of a current of the vapour of the solvent—each of these having certain advantages. T. H. P.

1909. *Molecular Weights of Carbon Compounds in Concentrated Solutions in Organic Solvents.* **C. L. Speyers.** (Amer. Journ. Sci. 13. pp. 213–223, March, 1902.)—The author has previously shown [see Abstract No. 1703 (1900)] that the equation $n/(N+n)=(p-p')/p$ (1) expresses the vapour pressures of mixtures of liquids miscible in all proportions better than does the equation $n/N=\log p/p'$ (2); $p-p'$ being the diminution in vapour pressure produced by the addition of n molecules of one liquid to N of the other. Since then von Zawidzki [see Abstract No. 171 (1901)] has applied Margules' equation to such mixtures, but the author considers that this is more complicated than equation (1) and gives no better results. As some disturbing element may have been overlooked in the development of van't Hoff's law when the solute is a volatile liquid, the author has made a number of measurements of the relative depression of the vapour pressure for concentrated solutions of non-volatile solutes. The boiling-point method giving unsatisfactory results with such concentrated solutions even when reduced pressures are employed the author makes use of a modified form of Walker's method. The results given refer to solutions of urea and resorcinol in water; urea, acetanilide and naphthalene in methyl alcohol; acetanilide, acenaphthene, naphthalene, urea, benzamide and resorcinol in ethyl alcohol; acenaphthene and naphthalene in propyl alcohol; naphthalene and acenaphthene in toluene. The numbers show that in no single case does formula (2) give very satisfactory results, but that this is sometimes the case with formula (1). The formula (1) is, however, an arbitrary one, as it makes use of the molecular weight of the solvent in the gaseous state and not that of the liquid solvent. The following equation, which the author now brings forward, only requires a knowledge of the molecular weight of the solvent in the vaporous state: $\log(n/N+1)=Q'(T_1-T_0)/RT_1T_0$; Q being the heat of vaporisation of one grammolecule of solvent from the solution the quantity of which is so great that no change in concentration is effected when the grammolecule is removed; T_1 represents the boiling-point of the solution, T_0 that of the pure solvent, and R is the gas solvent. The equation is available for determining either molecular weights according to the boiling-point method or the latent heat of vaporisation of the solvent. It answers all purposes to which van't Hoff's formula is put and is independent of the osmotic theory. T. H. P.

1910. *Position of Rare Elements in Mendelejeff's Periodic Syste* **B. Brauner.** (Jurn. Russk. Fisik. Chimičesk, Obščestva, 34. 1a. 2. pp. 4– and 2a. 1. pp. 142–153, 1902.)—The author examines all the possible positior of the metals of the rare earths in Mendelejeff's periodic system, the conclu sion arrived at being that this group of elements may present some analog with the group of asteroids in the solar system, forming, in the periodi system, a sort of link between cerium and the unknown element of the atomi weight 180. This interperiodical group is thus the continuation of the eight line, terminating with the wolfram-platinum elements ; gold is shown to b the first term of the ninth, and not of the eleventh line. The first elemen of the twelfth line is probably radium, followed by thorium and uranium.

A. C

1911. *Catalysis of Hydroxylamine and of Hydrazine.* **S. Tanata** (Zeitschr. Phys. Chem. 40. pp. 475–480, April, 1902.)—In cases of catalysis where there are bye-products it is conceivable that the catalyser may favou some one of the chemical changes in operation, so that the quantitative dis tribution of the products will be different with and without the catalyser The author presents the first accurately investigated case of this kinc Hydroxylamine solutions decompose on warming, chiefly according to th equation $3NH_2OH = N_2 + NH_3 + 3H_2O$. At the same time nitrogen monoxid is produced to a small extent according to the equation—

$$4NH_2OH = 2NH_3 + N_2O + 3H_2O.$$

It is found that if the decomposition takes place in presence of platinun black, nitrogen monoxide becomes the primary, and nitrogen the secondar product. The author suggests that the platinum is changed to a suboxide b oxygen from part of the hydroxylamine ; the oxide of platinum would the oxidise another part of the hydroxylamine. This explanation is not, however easily applied to the case of hydrazine (as sulphate), which also quickl decomposes, with evolution of nitrogen, in presence of platinum black: th hydrazine contains no oxygen for the formation of an oxide of platinum.

D. H.

1912. *Separating Crystals from Alloys.* **C. van Eyk.** (Konink. Akac Wetensch. Amsterdam, Versl. 10. pp. 859–862, April 19, 1902.)—After dis cussing the various methods used to ascertain the structure and constitutio of alloys, the author suggests separating crystals from the mother-liquor, b means of a centrifugal device, the temperature at which crystals begin t separate out from the molten alloy being previously determined. Thi method will in most cases afford a means of ascertaining whether pur metals, compounds, or mixed crystals are separated out, the composition c the crystals obtained changing regularly in the latter case. A. G

1913. *Limitations of the Mass Law.* **W. D. Bancroft.** (Journ. Phys Chem. 6 pp. 190–192, March, 1902.)—The author adduces cases to sho that, even where the molecular weight of each reacting substance i constant, and where Henry's law holds absolutely for each of them take singly, the orthodox mass law equation will not apply in the solution, if an one of the reacting substances influences the partial pressures of any of th others either positively or negatively. Nernst and Luther, in showing tha the dissociation of a compound in solution can be deduced from the dis

sociation in the vapour provided Henry's law holds for the compound and its dissociation products, had assumed Dalton's law, that each substance in the vapour phase is absorbed proportionally to its partial pressure and independently of the nature of the other absorbed substances, which is not always true. When this law holds, the effect due to the nature of the solvent will be seen in the change of the equilibrium constant, the more soluble system increasing at the expense of the other, which the author shows to be consistent with Berthollet's law. W. E. T.

1914. *The Phase-Rule.* **J. E. Trevor.** (Journ. Phys. Chem. 6. pp. 185–189, March, 1902.)—The author obtains a new derivation of Gibbs' phase-rule by considering the energy of each of the coexistent phases as a function of the volume, entropy, and component masses, and the differentials of these functions, and comparing the number of equations of condition that must be satisfied, with the number of the variables. W. E. T.

1915. *Synthetic Analysis of Solid Phases.* **W. D. Bancroft.** (Journ. Phys. Chem. 6. pp. 178–184, March, 1902.)—Reversing the method of van Bijlert [Zeit. Phys. Chem. 8, 343 (1891)], the author deduces the composition of a solid phase by analysing, and thus determining the change in composition of, the solution from which it separates. A second analysis with different initial and final concentrations decides whether the solid phase is a solid solution or a compound, as its composition varies in the former case. If a third component may enter into the solid phase, the results are best interpreted graphically. Sometimes direct analysis of the solution is difficult and it is better to employ a zero method. Thus an assumed constitution of the solid phase may be tested by adding to a saturated solution one or more components in the assumed proportions and keeping the solution at the adopted temperature until equilibrium is attained; if the assumed proportions are correct, the solution will be unchanged, as may be verified by determining any of its convenient properties. In the case of alloys, the breaks in the temperature-time cooling curves may be used and the alteration which is produced in them by the addition of one or more components. W. E. T.

1916. *Synthesis of Dimethyl-succinic Acid under the Influence of Light.* **W. Zermoff.** (Jurn. Russk. Fisik. Chimičesk, Obščestva, 34. 2a. pp. 140–142, 1902.)—Among the reactions occurring under the influence of light between organic bodies, there are some known cases of synthesis. The author investigates that of α-iodpropyl ether, which, on being exposed to the sunlight together with mercury, is converted into dimethyl-succinic acid. A. G.

1917. *Gelatinisation.* **S. Levites.** (Jurn. Russk. Fisik. Chimicesk, Obščestva, 34. 2a. pp. 110–119, 1902.)—The author studies the delay of gelatinisation of some colloidal bodies from an aqueous solution, produced by the addition of salts or other substances. It is shown that this effect increases with the temperature; in some cases, the gelatinisation process is found to be wholly prevented. The facts observed afford evidence of the proposition suggested by the author, that a given colloid will undergo gelatinisation from a given salt solution more slowly, the more readily it dissolves in this solution. Some striking analogies between this process and the process of crystallisation are finally pointed out. A. G.

1918. *Solubilities of Calcium Salts of the Acetic Series.* **J. S. Lumsden** (Chem. Soc., Journ. 81. and 82. pp. 350–362, April, 1902.)—The solubilities of the calcium salts of the first nine normal acids of the acetic series and of isobutyric and isovaleric acid were determined. The solubilities increase up to the propionate and then decrease again, the solubility of the butyrate being equal at 33° to that of the formate, whilst higher homologues are much less soluble. The formate separates in an anhydrous form, but all the other salts with $1H_2O$, though the acetate separates below 84° with $2H_2O$, the isobutyrate below 62° with $5H_2O$ and the isovalerate below 46° with $3H_2O$. In almost every case the solubility-curves are convex to the axis of temperature, and exhibit a temperature of minimum solubility.

T. M. L.

1919. *Decomposition of Organic Halogen Compounds in Alcoholic Solution by Sodium Amalgam.* **R. Löwenherz.** (Zeitschr. Phys. Chem. 40. pp. 399–439, April, 1902.)—In the experiments here described, a quantity of sodium amalgam was added to the alcoholic solution of an organic compound and a determination was made from time to time, in samples of the reaction mixture, of the quantity of sodium which had reached and of the quantity of halogen which had split off. A similar series of experiments has already been described by the author (Zeits. Phys. Chem. 32. 477, 1900), where sodium replaced the sodium amalgam: it was found that, with sodium, the course of the reaction was the same for all the compounds investigated, and could be expressed by the formula $k = 1/(\mathrm{Na}) \times \log\{a/(a-x)\}$, where k is a constant called the utility-effect (Nutzeffekt), (Na) is the dissolved quantity of sodium in gram-atoms in one kilogram of solution, a is the original quantity of the halogen body, x the quantity decomposed. In the case of sodium amalgam, it appears that the reaction is much more complex than with sodium, and cannot be expressed by the simple formula given above; the experiments made with iodobenzene showed that the decomposition was not proportional to the concentration except, possibly, for very small concentrations; no definite results could be obtained with bromobenzene as the results varied with the rate of stirring. An addition of water markedly influences the decomposition of iodobenzene by sodium, not by sodium amalgam, and the amount of decomposition of iodo- and bromo-compound is greater when the amalgam is used. In the latter case, too, the reaction is little affected by temperature, by the extent of surface of the amalgam, by the substitution of amyl for ethyl alcohol or of lithium or potassium for sodium; the concentration of the amalgam affected the decomposition of iodobenzene, not of bromobenzene.

D. H. J.

1920. *Aqueous Solutions of Inorganic Salts.* **W. Biltz.** (Zeitschr. Phys. Chem. 40. pp. 185–221, March 25, 1902. Communication from the Göttingen University.)—Determinations were made of the molecular depression of the freezing point, lowering of the vapour pressure at 25°, and elevation of the boiling-point of aqueous solutions of a wide range of salts. According to the simple laws of dissociation these effects should be greatest at great dilution approximating in the case of binary salts to twice the values for non-electrolytes, and for ternary salts to a threefold value. In a number of cases however, values are obtained for moderately strong solutions which are greater than the values in dilute solution, a minimum being reached at inter-

mediate dilutions [see Abstract No. 915 (1902)]; in some cases values are obtained in concentrated solutions which are even greater than those required for complete dissociation; thus, the molecular depression of the freezing-point for $MgBr_2$ in N/2 solution is 58·4, the value calculated for complete dissociation being only 55·5.

These effects are not very marked in the case of the alkaline chlorides; in the series Cs, Rb, K, NH_4, Na, Li, cæsium behaves most normally, but lithium (the least normal member of the series) shows a steady increase with increasing concentration in the molecular depression of the freezing-point; a similar gradation occurs in the case of the lithium and potassium salts of the radicles NO_3, Cl, Br, I, the nitrates being most normal and the iodides most abnormal. The chlorides of the divalent metal Ba, Si, Cu, Zn, Mn, Ca, Ni, Co, Mg, Fe all exhibit a pronounced minimum of molecular depression of the freezing-point at about 0·2N; the curves illustrating this are very striking, the minimum being least marked in the case of $BaCl_2$, and most in the case of $MgCl_2$ and $FeCl_2$.

General confirmation of the results obtained for the molecular depression of the freezing-point was obtained by studying the elevation of the boiling-point and lowering of the vapour pressure. In explanation of these very remarkable results it is suggested that the salt combines with the solvent to form hydrates, whereby the mass of the free solvent is materially reduced, especially in concentrated solutions, and the osmotic constants are correspondingly increased. In support of this view it is pointed out that the molecular heat of solution of the chlorides of the divalent metals Ba, Sr, Cu, Zn, Mn, Ca, Fe, Co, Ni, Mg, increasing from Ba to Mg, leads to an arrangement of these metals which differ from the cryoscopic arrangement given above only in the displacement of Fe and the interchange of Ni and Co. Moreover, the molecular heats of solution increase in the series K, NH_4, Na, Li, and with only two exceptions in the series NO_3, SCN, Cl, Br, I, the thermal arrangement of the binary salts being also in agreement with their cryoscopic behaviour. Opposite effects would be produced by polymerisation of the dissolved salt, as in the case of aluminium bromide, which in solution, as in the gaseous state, consists largely of Al_2Br_6. The most normal behaviour is found in the cæsium salts and in the nitrates, and the cryoscopic behaviour of cæsium nitrate was therefore determined; the value $\frac{\alpha^2}{(1-\alpha)v}$ was found to be constant up to 4·34N, and this salt is the first strong electrolyte that has been found to obey the dissociation law. The values of $\alpha\ \lambda/\lambda_\infty$ determined from the conductivity do not, however, give a steady dissociation-constant. T. M. L.

1921. *Inversion of Zinc Sulphate.* **H. T. Barnes** and **H. L. Cooke.** (Journ. Phys. Chem. 6. pp. 172–177, March, 1902.)—So far measurements of the temperature of inversion by means of the Clark cell have shown a marked difference from those obtained by measurements of solubility. Thinking that this might be due to the mercurous sulphate in the Clark cell, the authors constructed two H-form cells, one of which was filled simply with zinc sulphate crystals and solution over zinc amalgam, the other containing mercurous sulphate and zinc sulphate paste over mercury. The sulphate in one limb was inverted, and then the e.m.f. measured at various temperatures near the temperature of inversion. The results obtained for the two cells showed a small difference, but not so large as the difference in question. W. R. C.

1922. *Secondary Reactions in Gas-Cell.* **E. Biron.** (Jurn. Russk. Fisik. Chimičesk, Obščestva, 33. 6. pp. 424–480, 1901.)—In this paper the following combination—

Pt (saturated with air) || HCl (aqueous) || Normal electrodes

is investigated, the secondary reactions produced by the catalytic effect of platinated platinum electrodes being accounted for. The author maintains that the chlorine evolved at this electrode, and reacting upon it, causes the electromotive force of this cell to fall, which accounts for the abnormally small values of the same, as given by previous investigators. A. G.

1923. *Electromotive Forces of Metals in Cyanide Solutions.* **S. B. Christy.** (Elektrochem. Zeitschr. 8. pp. 49–58, June; 75–83, July; 104–108, Aug. 133–135, Sept.; 159–163, Oct.; 181–186, Nov.; 198–207, Dec., 1901; and pp. 221–231, Jan., 1902.)—The relative affinities of metals are measured by their tendency to dissolve in potassium cyanide solutions. The values of the e.m.f.s of a large number of metals, alloys, and minerals in cyanide solutions of various strengths are examined, and the result expressed by means of curves. Two methods are used for determining the electromotive forces. In the first case, a cell containing the cyanide solution, and the metal as electrode, is connected by means of a tube and siphon containing $\frac{M}{1}$ KCl solution with an Ostwald's normal electrode. This combination is placed in circuit with a large resistance varying from 30,000 to 200,000 ohms, and a Wiedemann galvanometer. The Ostwald's electrode was calibrated by means of a Latimer-Clark standard cell. Its e.m.f. was 0·560 volt. The e.m.f. found is either the sum or difference of that of the normal electrode and of the metal in the KCN solution, according as the currents from each are in the same or in opposite directions. The other method used was a Null method; the circuit consisted of two parts, one containing the combination of the cyanide cell and the normal electrode, the other in circuit with an accumulator having a constant e.m.f. of 2 volts. The position of a sliding contact, on a resistance divided into 10,000 parts, was altered until no deflection was produced in the galvanometer on closing the circuit. The results are best shown by means of curves, but a short summary of results is also given. The electrochemical order of the metals in $\frac{M}{1}$ or 6·5 per cent. KCN solution is zinc, copper, gold, silver, lead, mercury, iron, and is completely different from their order in distilled water. The latter is zinc, lead, iron, copper, silver, mercury, gold, and is the same as that in acid solutions, except that iron stands before lead. All these metals show a critical point which lies at a dilution of between M/1000 and M/10000 of the cyanide solution; at these points the potential of most of the metals changes from + to −; this would appear to be due to the fact that at this point the complex ions are completely dissociated. The form of the curves for iron and lead are different from those of the other metals; in the case of iron the results are not quite satisfactory, owing to the formation of deposits. The rest of the paper is devoted to the examination of the power of dissolving gold, possessed by cyanide solutions of different strengths. At the beginning of the paper there is a critical abstract of recent work on solution and ionisation. W. C. B.

1924. *Measurement of Ionic Velocities.* **B. D. Steele.** (Roy. Soc., Phil. Trans. 198. pp. 105–145, Feb. 13, 1902. Abstract in Roy. Soc., Proc. 68. pp. 358–360, July 9, 1901.)—This paper is largely a recapitulation of previously published work [see Abstract No. 1555 (1901)]. The author obtains for the sums of the anion and kation velocities numbers which agree well with those calculated from Kohlrausch's conductivity figures. The ratio of the current as measured and as calculated from the velocity of the margins is equal to unity for a few salts of the potassium chloride type, but for other salts the ratio is sometimes greater and sometimes less. The author shows that where a change in transport number occurs with changes in concentration, this is due to complex ions rather than to a change in ionic velocities. It was observed that the melting-point of the jellies depended on the nature of the anion and the kation, being more or less additive. W. R. C.

1925. *Voltameters with Antimony, Bismuth, and Cadmium Electrodes.* **G. A. Berti.** (Elettricista, Rome, 11. pp. 100–102, April, 1902.)—The phenomena observed in voltameters which have electrodes of aluminium or magnesium, placed in an electrolyte yielding oxygen at the anode, have been known for some time [see Abstracts Nos. 1159 (1901), 749 (1902)]. The author has observed quite similar phenomena with electrodes of antimony (in presence of acid, alkaline, or ammoniacal electrolytes), of bismuth, and of cadmium (with ammoniacal electrolytes). Neutral oxalate of ammonium forms the best electrolyte for cadmium, ammonium carbonate for bismuth and ammonium carbonate or sulphuric acid for antimony. The following table gives some of the results obtained with a voltameter containing sulphuric acid (sp. gr. 1·298), in which were immersed an antimony anode (12 cm.²) and a platinum kathode (9 cm.²) placed at a distance of 4·5 cm. from one another :—

P.D. at electrodes	5·9	9·62	13·2	22	35	38·4	43·5	45 volts.
Current	0·034	0·054	0·073	0·148	0·256	0·56	6·45	9·2 amperes.

The luminous phenomena began a little above 38 volts and increased till, at about 45 volts, there was the appearance of a beautiful fluorescence at the anode. D. H. J.

1926. *Tests of Improved Voltameter.* **T. W. Richards** and **G. W. Heimrod.** (Amer. Acad., Proc. 37. pp. 415–443, April, 1902.)—The improved silver voltameter, in which the anode is surrounded with a porous pot, has already been described [see Abstract No. 889 (1900)]; the present paper records a series of tests made with the instrument. These show (1) that the mean difference between two such voltameters in series amounts to only 0·004 per cent.; (2) that the deposit is unaffected by coating the lower part of the cup with paraffin, in order still further to reduce the possibility of contaminating the kathode-liquor by complex products formed at the anode; (3) that the average difference on using a zinc in place of a silver anode is only 0·001 per cent.; (4) that results differing on the average by less than 0·004 per cent. are obtained when an anode plate is placed *below* a wire-gauze kathode; this device, though troublesome, serves equally well to prevent contamination of the kathode by the heavy products formed at the anode, and the identity of results shows that no new error is introduced by the use of the porous pot. The conclusion is drawn that the porous cup voltameter affords a means of depositing the amount of silver which really corresponds to the quantity of electricity sent through it. An investigation of the separate effect of each anode irregularity showed that nitrite is formed at the anode

($AgNO_3 + 2Ag = AgNO_2 + Ag_2O$), but probably has no effect on the de posit; a solution *saturated* with nitrite gives a heavier deposit, as the nitrit decomposes in the light with separation of silver; the formation of nitrit tends to neutralise an acid solution, as was observed by Roger and Watso with 30 per cent. $AgNO_3$, but in dilute solutions acid is produced. Th main irregularity is apparently the formation of a complex ion such a Ag_3O^+, which when deionised at the kathode would deposit, in the form o $Ag + Ag_2O$, more than three times the normal weight of material; this viev involves the formation in the solution of a basic salt such as Ag_2O, $AgNO_3$ and is in accordance with the facts (1) that the anode irregularity is accom panied by liberation of acid; (2) that similar high values result when th solution is saturated with Ag_2O; (3) that normal values are again obtaine when the boiled solution is afterwards acidified; (4) that very high result were obtained by Rayleigh in presence of silver acetate, which would pre vent the separation of any acid stronger than acetic, and would therefor favour the formation of basic salt. In Rayleigh's voltameter the deposi on silver is 0·01 per cent. heavier than on platinum; this difference does no occur in the improved voltameter, and is therefore due to the formation a the anode of a compound from which silver is readily deposited as if from supersaturated solution. That this is actually the case was proved by trans ferring the anode solution to a platinum crucible containing deposited silver when it was found in four successive experiments to deposit on the averag 0·33 mg. of silver or some silver compound; silver nitrate solution through which no current has been passed does not produce this effect. The forma tion at the anode of a silver-depositing complex would also account for th copious formation of anode-dust. It is suggested that the silver at the anod dissolves largely as Ag_3^+, and that this unstable ion breaks down with liberatio of silver, mainly at the anode, but also at the kathode if allowed to reach th latter. The existence of a "peroxide" is also referred to as a fourt irregularity. The loss in weight of the deposits when ignited averaged 0·018 per cent., due to included mother-liquor; this is of importance wher absolute results are required, but for purposes of comparison the unignite precipitates may often be used. The true electrochemical equivalent o silver is probably 1·1175 mg. per coulomb, and the number of coulombs pe equivalent 96,580. The electrochemical equivalent of copper, by comparison with silver deposited in series, is 0·32929 mg. per coulomb, correspondin with an atomic weight 63·601 (Ag = 107·92, O = 16·00) as compared with th value 63·604 deduced from atomic weight determinations. T. M. L.

1927. *Conductivity of Solutions of Mixed Electrolytes.* **H. Wolf.** (Zeitschr Phys. Chem. 40. pp. 222–255, March 25, 1902.)—The lowering of the electrica conductivity of a dilute aqueous solution (0·0282N) of KCl or NaBr, amount to about 8·2 per cent. for each equivalent of acetic acid added to 1 litre o solution, after allowing for the conductivity of the acid. The increase o viscosity amounts to 12·3 per cent. for each equivalent of acetic acid (Reyher Zeitschr. 2. 757, 1888) or $\frac{3}{2}$ times as great as the decrease of conductivity.

The decrease of conductivity by the addition of alcohol is 13·5 per cent per equivalent per litre; and the increase of viscosity (Arrhenius, Zeitschr. 1 298, 1887) is 26·8 per cent., the ratio here being 2:1. In the case of mor concentrated solutions (0·25N and 0·50N KCl) the lowering of conductivity b alcohol is almost constant at 13·9 per cent. per equivalent per litre, but th lowering of conductivity by acetic acid increases to 9·7 and 10 per cent.

probably in the latter case there is a more marked lowering of the degree of dissociation of the salt, than in the former case, the dielectric constant of alcohol being higher than that of acetic acid. [See also Abstract No. 1161 (1902).] T. M. L.

1928. *Limiting E.M.F.'s in Electrolysis.* **Berthelot.** (Comptes Rendus, 134. pp. 873–876, April 21, 1902.)—Experiments are described on the decomposition of acidulated water, and also of a neutral salt, at atmospheric pressure and in vacuo, using platinum wires as electrodes (Wollaston electrodes). Gas is not evolved at both poles with 1·5 volts, even in vacuo, but evolution takes place with 1·6 volts. When pyrogallol was present at the positive, hydrogen was evolved at the negative between 0·80 and 0·70 volt. The e.m.f.'s were found by knowing the e.m.f.'s of the cells applied, apparently not by measurement. W. R. C.

1929. *The Rhodin Electrolytic Process for Manufacture of Alkali and Bleach at Sault Sainte Marie, Ontario.* **B. E. F. Rhodin.** (Soc. Chem. Ind., Journ. 21. pp. 449–451 ; Discussion, p. 451, April 15, 1902.)—A paper read by the author before the first meeting of the Canadian section of the Society in Toronto on March 6, 1902. The power used at these works is derived from the fall of 19 ft. at Sainte Marie, and the power costs 0·136 cents per lb. of manufactured products. The cells are of the ordinary Rhodin type, and each takes a current of 800–1,000 amperes at an e.m.f. of 5 volts. The inner chamber of each cell is 3 ft. in diameter, the outer cell is 5 ft. Acheson graphitised carbons are employed as anodes, and the hydrogen produced by secondary reactions in the cell only amounts to 3 per cent. of the chlorine. The present power plant of the company consists of three 220-kw. generators, each driven by a separate turbine. The decomposing plant consists of 120 cells, while the bleaching powder is produced in 10 chambers of the usual design. In 1901 only a portion of the plant was operated, the daily output being 4 tons 800 lbs. bleach, and 2 tons caustic soda. The bleach produced contains 37–38 per cent. available chlorine, and the caustic 74–76 per cent. Na_2O. As soon as commercial conditions permit, the whole plant will be operated. With each cell taking 1,000 amperes at an e.m.f. of 5 volts, the 120 cells are calculated to yield 9 tons 241 lbs. bleach, and 4 tons 565 lbs. caustic soda per day. This output would nearly meet the present Canadian demand for these products.

Discussion.—**Rosebrugh** pointed out that the theoretical decomposing value of NaCl in aqueous solution with a mercury kathode was 4·06 volts, and that the counter e.m.f. produced by the decomposition of the resultant sodium analgam was lost in the Rhodin cell. **Lang** drew attention to the fact that all electrolytic processes yield more chlorine per ton of caustic alkali than the old Le Blanc process, and that the difficulty in disposing of the bleaching powder produced would check their growth and development. J. B. C. K.

1930. *The Acker Electrolytic Alkali Process.* **C. P. Townsend.** (Elect. World and Engineer, 39. pp. 585–587, April 5, 1902.)—This is an illustrated article describing the Acker fusion process as operated at Niagara Falls with 325 h.p. After referring to the earlier attempts of Rogers, Borchers, Vautin, and Hulin to solve the problem presented by the electrolysis of fused salt with a kathode of molten lead, the author gives details of the Acker cell. [See Abstract No. 142 (1902).] The anodes, of which there are four in each furnace or pot, are of graphitised carbon, and are made by the Acheson

Company. Each anode has a working face 7½ in. × 14 in., and carries current of 2,000 amperes.

The furnaces are lined with magnesite blocks, set without cement; th molten salt penetrates the joints, and, on solidifying, acts as binding materia The plant at Niagara now comprises forty-five furnaces, and eleven more ar provided for. The energy is supplied by the Niagara Falls Hydraulic Powe Company in the form of an 8,000-ampere current at 300 volts, and is trans mitted to the alkali works by bare aluminium cables.

Each furnace requires an e.m.f. of 7 volts, and with a current o 8,000 amperes at this voltage, it absorbs 75 e.h.p. The average productio of anyhydrous caustic soda per day under these conditions is 581 lbs Settling is required, but no boiling down, to prepare this caustic for th market.

The output represented by the above figures is equivalent to a curren efficiency of 93 per cent., and to an energy efficiency of 55 per cent. Owin to the higher e.m.f. theoretically required to work the fusion process thi latter efficiency cannot be usefully compared with the energy efficiency c 52·3 per cent. given for the Castner-Kellner alkali process. The work of the Acker Process Company at Niagara Falls were started in Decembe 1900, and have been in continuous operation since that date, with th exception of one week's stoppage, owing to fire in the power-house.

J. B. C. K

1931. *Manufacture of Barium Compounds in the Electric Furnace.* **C. H Jacobs.** (Soc. Chem. Ind., Journ. 21. pp. 391–392; Discussion, p. 392 March 31, 1902.)—In the older methods of converting barytes into solubl barium compounds, the $BaSO_4$ is reduced to BaS by heating with coal o coke in a retort furnace; in this way, from 65 per cent. to 75 per cent. of th available sulphate is obtained as soluble sulphide, which is then converte into the other soluble barium salts. According to the patented process o the United Barium Company, Niagara Falls, N.Y., barytes is reduced in th electric furnace, and 97 per cent. to 99 per cent. of the sulphate obtained in soluble form. The reaction on which the process is based is as follows:—

$$3BaSO_4 + BaS = 4BaO + 4SO_2.$$

This takes place so completely, on fusion in the electric furnace, that th product contains not more than 2 per cent. to 3 per cent. of unaltered $BaSO_4$ and frequently not more than 1 per cent. Owing to the high temperature used, it is necessary to employ a carbon-lined furnace, with the result tha enough of the $BaSO_4$ is reduced to BaS to destroy the equilibrium of th above reaction. In actual practice it has been found more economical t mix ground barytes and coke in equal molecular proportions. On heatin the mixture, the following reaction takes place:—

$$4BaSO_4 + 4C = 3BaSO_4 + BaS + 4CO.$$

The resulting $BaSO_4$ and BaS then react according to the first-mentione equation—

$$3BaSO_4 + BaS = 4BaO + 4SO_2.$$

The furnaces used are a new type of continuous electric furnace; they ar tapped periodically, similarly to an iron blast furnace; the maximum powe consumption is 500 kilowatts, and the maximum output 8 tons of furnac product per twenty-four hours. The product is dissolved in hot water, an

the insoluble impurities filtered off. The solution deposits crystals of $Ba(OH)_2 + 8H_2O$; these are washed free from sulphydrate by spraying with cold water, dried and melted. The resulting crystallised barium hydrate contains less than 1 per cent. of impurities. The chief uses of the hydrate are in the white pigment and dry-colour trades, purification of water for industrial purposes, and in the recovery of sugar from beet sugar molasses. A new white pigment, derived from the hydrate, is said to be superior to "blanc fixe" or ground barytes in covering power, but its composition is not given. W. C. B.

REFERENCES.

1932. *Liquefaction of Gaseous Mixtures.* **F. Caubet.** (Zeitschr. Phys. Chem. 40. pp. 257–367, March 29, 1902. From the French.)—In this paper the author gives an account of the present state of the theory of the subject, and of his own experimental work on the three groups of mixtures, carbon dioxide and sulphur dioxide, carbon dioxide and methyl chloride, methyl chloride and sulphur dioxide [see Abstracts Nos. 843 and 2004 (1900) and No. 910 (1901)], of the apparatus employed, and the degree of accuracy of the observations. W. E. T.

1933. *Physico-Chemical Studies of Tin. VII.* **E. Cohen.** (Konink. Akad. Wetensch. Amsterdam, Versl. 9. pp. 438–439, 1902.)—This article is a continuation of previous researches by the same author. A striking case of zinc corrosion is recorded, and details of former investigations are given. [See also Abstract No. 1563 (1901).] A. G.

1934. *Nomenclature of Metallography.* (Iron and Steel Institute, Journ. pp. 1–28, May, 1902.)—This is a most valuable glossary, drawn up by an international committee appointed by the Council of the Institute, in English, French, and German, in the hope that it will tend to promote the unification of terms, the simplification of those used, and the elimination of many of them. G. W. DE T.

1935. *Resistance and Viscosity.* **G. Gouré de Villemontée.** (International Physical Congress at Paris, Report, 4. pp. 84–102, 1900–1901.)—This paper gives an account of the experimental work which has been carried out in order to investigate the connection between the electric resistance of a saline solution and its viscosity —work originally aimed at the verification of Wiedemann's law, but now at the determination of the state of ionisation of solutions. W. E. T.

1936. *Electrochemical Polarisation.* **C. J. Reed.** (Frank. Inst., Journ. 153. pp. 259–268, April, 1902.)—This is a general discussion of the various definitions usually given of polarisation, which the author regards simply as a progressive change, due to the progressive exhaustion of the reagents. W. R. C.

1937. *Electrical Energy Direct from Coal.* **J. Wright.** (Cassier, 21. pp. 465–472, April, 1902.)

1938. *Manufacture of Parabolic Reflectors by Electro-chemical Methods.* **C. Rost.** (Elektrochem. Zeitschr. 8. pp. 263–272, March, 1902.)—A short historical summary of work done in this field, with a detailed account of the Cowper-Coles process for the manufacture of Palladium reflectors, previously described in various English papers. O. J. S.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

1939. *Balancing of Engines.* **W. E. Dalby.** (Mech. Eng. 9. pp. 731–736 May 31, 1902. Paper read before the Institution of Naval Architects.)—This is a sequel to the author's previous papers on balancing of engines, and deals with the questions of the increase of weight of the moving parts of engines of the usual types when masses are added to neutralise the unbalanced forces and couples, the change of weight introduced when the conditions of balance are satisfied in the original design so that no balance weights are necessary, and the changes in the form of the crank effort diagram to be expected when the crank angles are set to satisfy the conditions of balancing. Five types of triple-expansion engines are considered. A being a three-cylinder engine with cranks at 120°, B, C and D, four-cylinder engines with cranks at right angles, but in various sequences, and E a four-cylinder engine of the Yarrow-Schlick-Tweedy type, where the four cranks are set so as to balance among themselves. The necessary weight of moving parts is given in detail, the total being 9 tons for type A, 9·93 tons for B, C or D, and 10·27 tons for type E, for engines of the same power of 1,750 i.h.p. at 90 r.p.m. Of these, however, type E is balanced as it stands, while in the others there are large unbalanced forces and couples ; in order to balance these as well as possible, additional weights would be required varying from 52 per cent. in type A to 15 per cent. in type C. Detailed diagrams of the unbalancing forces and of the crank efforts (calculated from the cards and allowing for inertia) are given. In conclusion the author states that type E stands alone in having the unbalanced forces and couples in both vertical and horizontal planes practically *nil*, since in the other types the addition of masses to produce a balance in the vertical plane tends to increase the want of balance in the horizontal plane ; and that the crank effort from this type can be made as uniform as that from any other four-cylinder type. [See also Abstract No. 2243 (1901).] H. R. C.

1940. *Speed Variations and Relative Angular Displacements in Prime Movers.* **F. Klönne.** (Elektrotechn. Zeitschr. 23. pp. 287–292, April 3, 1902.)—The author points out that in the case of prime movers required for driving alternators intended to run in parallel, it is frequently specified that the speed variation shall not exceed a certain limit. This can hardly be regarded as satisfactory, since what is *primarily* of importance in parallel running is relative angular displacement of the generator armatures with respect to the field-poles, and not mere speed variations. It is true that the latter are the cause of the former, but the relation connecting the two is by no means simple, and depends on the way in which the working strokes of the engine follow each other. The author investigates this relation by a graphical method, assuming that the crank-effort diagram of the prime mover is given, and shows how to calculate the moment of inertia of the rotating part in order that its angular displacement (*i.e.*, its maximum displacement from the position of an assumed uniform speed) may not exceed a given limit ; this limit is stated to be taken as $\pm 3°$ of phase-difference by a well-known firm. A number of numerical examples are worked out in illustration of the author's theory. A. H.

1941. *Steady Running of Steam-engines.* **van der Stegen.** (Soc. Belge Elect., Bull. 19. pp. 14–42; Discussion, pp. 42–46, Jan., 1902.—In this paper the author divides into four classes the irregularities to which the running of a steam-engine is subject: (1) Cyclical variation of speed per revolution, produced in reciprocating engines by the periodic variation in the crank effort. This irregularity is limited solely by the moment of inertia of the flywheel, the action of the governor having no effect upon it. (2) Irregularity due to want of isochronism in the governor. (3) To want of sensitiveness in the governor, and (4) to inertia and instability of the governor. In certain cases these two last factors may be cumulative in their effects. Taking these different causes of irregular running in turn, the author first alludes to the well-known method by which, from the curves of tangential crank effort and of resistances, the maximum variation of kinetic energy of the flywheel, and consequently of speed, may be deduced. In the case of central station polyphase plants this method is insufficient, as it is not only the variations of speed, but the lag or lead of the flywheel with respect to the mean position it would assume at uniform speed, which is important. In this connection the author discusses the "coefficient of regularity" [see Abstracts Nos. 568, 940, and 942 (1902)], coming to the conclusion that any alteration of the accepted definition of this is at present inadvisable. The curve of periodic displacement is shown to be deducible from that of velocity by simple integration; as regards the question of the base-line from which the ordinates of the displacement curve should be measured, this ought to be the position assumed by an alternator running in perfect coincidence of phase on an infinite network. To determine this by analysis is a matter of some difficulty, but it will be very near the truth if the base is so chosen that the integral of the oscillation curve is zero; this is to assume that the synchronising torque is equivalent to an elastic coupling, the pull of which is proportional to the angular displacement. This is better than assuming that the displacement is one-half of the total oscillation, which is only true when the curves are perfectly sinoidal. Coming to the practical question, the engine builder has to determine the relative oscillations of the flywheel, not as they would be if only the inertia of the flywheel, the steady load, and the crank effort were taken into account, but as they are affected by magnetic actions brought into play by the displacements themselves. In this connection the conclusion of Boucherot is referred to, namely, that in a single-cylinder engine, when the diagram of crank effort approaches a true sinoidal curve, the displacements are always *increased* by the synchronising currents, and an explanation is given of this apparently paradoxical result. If in such a case the relative oscillation period of the alternator under the action of the synchronising couple coincides with the periodic fluctuations of the crank effort, "electromagnetic resonance" is set up and parallel running becomes impossible; even if this synchronism does not exist for the fundamental vibrations, it may do so in the case of the harmonics, with the result of increasing the oscillations to a dangerous extent. With multiple-crank engines, the curve of oscillations generally deviates considerably from the sinoidal form, and there is less danger of resonance. With machines driven by belts the effect is less marked than in the case of direct-driven plants; but even here it may be serious, as the elasticity of the belt cannot accommodate itself to too great variations. An interesting parallel (purely mechanical) of electro-mechanical resonance is given where a two-crank engine drove a main shaft by toothed gearing. The two ends of the shaft drove, by belting, two distinct sets of machinery, and it was found that the coefficient of regularity of the engine

being about 1 per cent., while at one end of the shaft the irregularity was less than this, as is usually the case, at the other end it was greatly accentuated, the probable cause being the thrashing of a belt in synchronism with the impulses of the engine. The evil was cured by giving different admissions to the two cylinders, thus rendering the impulses irregular, and destroying the synchronism with the beats of the belt. Discussing the remedies for electro-mechanical resonance, it is pointed out that multiplication of cranks, and their arrangement at suitable angles, is desirable in the case of poly-cylindrical engines; two single-cylinder engines coupled are more regular than a single unit of twice the power of either, and similarly with compound tandem engines. The best angle between the cranks for two-cylinder engines is usually not 90°, but 100° or 110°; the reason being that the mean impulse in the larger cylinder usually occurs at a point further removed from the dead centre than in the case of the high-pressure cylinder; the best angle can only be determined by trial. With two-crank compound engines the regularity varies considerably with the load, since the division of load between the cylinders is different at different loads, particularly with a fixed cut-off on the high-pressure cylinder. Reference is made to an engine of 10,000 h.p. by the American firm of Allis, in which with only two cranks there are eight dead-points and eight impulses per revolution. This is effected by arranging the four cylinders, two on each crank, with the two high-pressure cylinders horizontal and the two low-pressure vertical: the cranks are set at 135°. The result is an almost perfectly regular turning moment. The inertia of the reciprocating parts is of considerable importance with the high speeds now common. The evil may be counteracted to some extent by weighting the cross-head. Inequality in the admission is a remedy not to be recommended from the point of view of economy of steam consumption. It is important to avoid too great inequalities between the admissions at the two dead-points at different loads. These inequalities arising from the obliquity of the connecting-rod, can be got rid of by certain compensating devices. Three diagrams are given, showing in the case of a pair of coupled tandems the curves of speed and displacement: (1) with the weights (crank and half the connecting-rod) counterbalanced, (2) with these weights not counterbalanced, and (3) with a resistance chosen so as to give the greatest possible regularity. Comparing the diagrams, the most unfavourable conditions for regularity is seen to be the first, with the weights counterbalanced. A weight of 200 or 300 kg. on the rim of an alternator of not less than 40 tons would be sufficient to give the best results from the point of view of regularity, though such a method has disadvantages with regard to starting and stopping. This part of the paper concludes with a reference to apparatus which has been designed to measure cyclical variation in speed and flywheel displacement, a brief description being given of Cornu's arrangement (see Abstract No. 944 [1902]). (2) *Irregularity due to want of isochronism in the governor.*—A perfectly isochronous governor of the ordinary type would be inadmissible; but it is desirable to get as near to it as may be without increasing to an undue extent the disadvantages which attend certain ways of doing this. Thus if it attempted to restrict the range of the sliding sleeve, the power of the governor is reduced; if the range is preserved, but the dimensions of the governor are increased, inertia plays too great a part and the sensitiveness is reduced. An arrangement is described by which with the help of an auxiliary electro-motor, almost perfect isochronism may be secured, but it has the disadvantage of not acting *directly* on the governor. Moreover, too great a degree of isochronism introduces difficulties into

parallel running in polyphase stations, as the slightest mechanical disturbance of the governors, owing to their inertia and the resulting instability, deranges the steam admission, causing reciprocal action between the alternators and large synchronising currents. For the operation of paralleling alternators it is usually necessary to be able to modify the speed by an adjustment of the governors, which is generally done by moving a weight either by hand, or, in some cases, by the switch-room attendant with the aid of a small electro-motor; two methods of doing this are described. (3) *Want of sensitiveness in the governor.*—"Sensitiveness" is defined as the property in virtue of which the governor seeks to occupy at every instant the position of equilibrium corresponding exactly to the speed of rotation of the engine at that instant. Inertia and friction are the causes which make against sensitiveness; hence valves with trip-gear, by allowing these to be reduced to a minimum, conduce to sensitiveness in the governor. (4) *Inertia and instability.*—It is shown how these causes tend to produce hunting, with its attendant evils as regards parallel running; the question of limiting these oscillations, both as regards period and amplitude, is one best decided by experiment. With a governor of given type and dimensions, on a given engine, the most important way of increasing the stability is by the addition of an oil-brake or dashpot, the *rationale* of whose working is described. Lately these have been made with special valves by which the braking action is diminished in the case of very sudden variations of load; when the governor has nearly attained its position of equilibrium the valves close automatically, and the governor comes slowly to its final position. But while rendering the governor dead-beat the dashpot does not cure, but rather accentuates any sluggishness. In this connection another function of the flywheel is referred to, that, namely, of reducing oscillations due to the governor, and it is shown how the moment of inertia which the flywheel ought to have in order to annul these oscillations may be calculated if the time taken by the governor in passing from one position to the other is known; and it is explained how in high-speed engines a flywheel which may be sufficiently heavy to give the required regularity per revolution may be too light to prevent hunting of the governor due to change of load. Designers should therefore calculate the moment of inertia required for each purpose and adopt the highest value—multiplication of cranks, while providing a partial remedy for the first evil, has no effect on the latter. A discussion followed the reading of the paper, which is illustrated by curves and diagrams. B. P. S.

1942. *Engine Requirements for the Parallel Operation of Alternators.* **E. M. Tingley.** (Elect. Rev. N.Y. 40. pp. 730–731, May 31, 1902.)—The author in this paper gives the text of, and discusses the points raised in, a specification which the Westinghouse Company have issued for the guidance of engine builders, and which crystallises the results of their experience in regard to the points to which the latter should pay special attention when designing engines to drive alternators in parallel. The four headings included in the specification are (*a*) *The Governors*, which should not have any tendency to cause surging of load between one engine and another, or to maintain or increase such surgings if otherwise set up. In this connection the author discusses the general question of the "pumping" of alternators in parallel, or of synchronous motors and rotary converters fed from them, showing how the governors may in certain cases accentuate the evil by resonance. Usually, increased flywheel action decreases the tendency to pumping, but in certain cases, by increasing the resonant effect, this may have the opposite result.

(*b*) *Flywheel displacement.*—The total variation, positive *plus* negative, of the position occupied by any radius of the flywheel from that which it would occupy if the rotation were absolutely uniform, should not exceed 3° for a two-pole machine, 1·5° for a four-pole, 1° for a six-pole, and so on; or generally, one-sixtieth of the pitch angle of two consecutive poles. This limit is not really too small; some authorities give a value one-sixth less than this. (*c*) *Percentage drop of speed* with load should be the same for all engines which have to run in parallel. This condition is necessary to ensure that each alternator should take up its proper share of the load. (*d*) *Governors* should be adjustable while running. This is advisable, as the engine governors will usually vary in their own adjustment, and it is necessary to correct this from time to time so that the load may be properly divided; also with this adjustment the load is much more easily transferred for purposes of synchronising or separating machines. [See also preceding Abstract.] B. P. S.

1943. *Straining Forces on Crank-Shafts.* **S. Dunkerley.** (Engineering, 73. pp. 402–403 and 426–428, March 28; 454–458, April 4; and pp. 491–494, April 11, 1902. Paper read before the Institution of Naval Architects.)—The author investigates all the straining actions on a crank-shaft; the different twisting moments in the different portions, and the bending (allowing for the continuity of the shaft at the bearings by means of the theorem of three moments). An actual case of a crank-shaft of a four-cylinder triple expansion marine engine is worked out in full. The cranks of the engine were arranged at the angles necessary to balance the reciprocating parts. The forces are estimated from indicator cards taken when the engine was working at 10,300 h.p. Diagrams of the turning moments (corrected for inertia and weight of the reciprocating parts) and of the bending moments are given, and the diagrams of equivalent twisting moments and tables of maximum stresses are deduced. The engine considered had one low-pressure cylinder in front of the high pressure, and a remarkable feature of the results is that the greatest equivalent twisting moment occurs at the high-pressure crank, and not at the after low pressure as would be naturally expected. H. R. C.

1944. *Liquid Fuel for Steam Purposes.* **J. S. S. Brame.** (Nature, 66, pp. 186–188, June 19, 1902.)—This paper recounts the general advantages of oil for fuel [see Abstracts Nos. 1547 (1900), 546, 1375 (1901), and 950 (1902)], quotes Aydon's classification of the methods of using it, and refers specially to its use on railways, notably the Grazi-Tzaritzin Railway of Russia and the Great Eastern of England, and to some instances of its use in the Mercantile Marine. [See Abstract No. 1766 (1902).]

With regard to the calorific value of oil, the author remarks upon the omission, from calculations of the theoretical heat value, of allowance for the physical condition of the fuel. [See also Journ. Soc. Chem. Indus. vol. vii. pp. 195–200.] F. J. R.

1945. *Liquid Fuel.* **R. G. Paddock.** (Mech. Eng. 9. pp. 842–843, June 21, and pp. 875–876, June 28, 1902. Paper read before the Technical Society of the Pacific Coast.)—The author reviews the history of the subject from its commencement in the United States in 1861 or 1862, referring to the plans of Shaw and Linnton, Foote, Dorset and Blyth, Thwaite and others in America and Britain; Leng, Artemeiv, Karapetov, and Urquhart in Russia

and experiments in France, Italy, and Germany. He decides against efforts to convert the oil into gas before combustion, and in favour of the spraying system combined with preliminary settling of the oil, to separate water from it, and heating of the oil. The most recent systems introduced into steamships are those of Flannery-Boyd and of Orde, the latter being the more efficient. In this system the oil is passed through a settling tank, from which it is pumped to the burners under a pressure of 60 lbs. Before reaching the burners, it is heated, principally by waste heat, to a temperature just below its boiling-point, and on emerging from the inner tube of the burner, it is met by steam and air heated to 600° F., or more if needed, and is wholly converted into vapour. With Borneo oil of 18,800 B.Th.U. an evaporation of 16 lbs. has been obtained, the waste gases showing 13·2 per cent. CO_2, 3·6 per cent. oxygen, and 83·2 per cent. nitrogen. The introduction of the Körting system in steamers of the Hamburg-American line is also referred to. The metallurgical furnaces in Pennsylvania have several years' record of successful use of oil for reheating, and even for open hearth steel-making. The furnaces have to be carefully designed according to the degree of heat wanted, and for welding, the use of steam for spraying is bad. With superheated steam, however, iron may be melted without undue loss by oxidation. Regarding the characteristics of different oils the following facts are given :—

	California.	Russia.	Texas.	Borneo.
Gravity.....	16° B.	—	25°–30° B.	32° B.
Flash point.....	275°–300° F.	—	135°–150° F.	200°–220° F.
Mean boiling-point	500° F.	—	170°–190° F.	390°–410° F.
Thermal value from analysis and calorimeter test	18,300 to 18,800 B.Th.U.	19,000 to 20,000 B.Th.U.	18,500 to 19,000 B.Th.U.	18,800 to 19,000 B.Th.U.

Carefully conducted evaporative tests gave :—(1) Vaporisation system, Borneo oil 32° B. theoretically possible from and at 212° F. 19·46 lbs. Highest net result 16 lbs. (2) Vaporisation system, West Virginia oil 40° B. Theoretical 21·7 lbs. Net 16·5 lbs. (3) Steam spraying system, warm air for combustion. Texas oil 25° B. Theoretical 19·77 lbs. Highest net 15·16 lbs. Assuming 18,600 B.Th.U. average for California oil 16° B. or a theoretical of 19·25 lbs. ; 14·8 lbs. with spray systems and 15·7 lbs. with vaporisation is as much as can be expected. [See also preceding Abstract.]

F. J. R.

1946. *Separation of Oil from Condensed Steam.* **J. R. Bibbins.** (Eng News, 47. pp. 406–409, May 22, 1902. Paper read before the Detroit Engineering Society, Jan. 24, 1902.)—Oil is carried from engine cylinders and valves through condensers in the form of free oil, and also in that of an emulsion with water. In order to arrive at the best method of separating it in both forms from the water to be returned to the boiler, extensive experiments were carried out at Station "C" of the Detroit Edison Company with condensing plant consisting of a 1,600-sq. ft. Worthington surface condenser attached to two tandem compound engines of 400 h.p. When the water of condensation was sent through a coke filter, consisting of a cylinder 14 in. diameter and 10 ft. high filled with coke of pea-nut size, except for a short length at either end which formed settling chambers, oil gradually accumu-

lated on the sides of the cylinder and passed into the boilers. The emulsion was not stopped by the filter. It was found that a temperature of 265° to 280° F. caused the separation of the oil from the water, but 215° F. produced no result. Submitting the emulsion to pressure, vacuum and aeration produced no effect. Collection of samples of steam from the exhaust-pipe at different depths showed that no free oil was there, and emulsion occurred only at or near the bottom of the pipe—the exhaust steam at the top of the pipe being pure steam. A steam trap at the lower end of the receiver between high- and low-pressure cylinders caught all the free oil. It is supposed, however, that either the heat of the dry surfaces of the exhaust-pipe or some action in the condenser may cause separation of oil and water and account for the free oil found in the filter. Chemical tests showed that precipitation of the oil by means of calcium compounds such as powdered chalk or marl was rapid and satisfactory. Fuller's earth also acted efficiently, but more slowly. Different designs of oil separators such as those of Baum, Bundy, and Cochrane are described, and the Bundy automatic trap is commended for use in conjunction with Bundy and Cochrane separators in a vacuum system. The author recommends that all oily drips from engines, pumps, reheaters, and separate traps should be separately purified; and some short notes on the purification of feed-water are included in the paper. Illustrations of the filter and of the apparatus used in the experiments accompany the paper. F. J. R.

GAS AND OIL ENGINES.

1947. *Algrin Motor.* **L. Fournier.** (Locomotion Automobile, 9. pp. 341–343, May 29, 1902.)—This is an alcohol engine, having three cylinders—two power cylinders, and one compressor. The stroke of the compressor piston, and consequently, the quantity of compressed gas admitted to a power cylinder, can be varied by hand while the engine is running. In this manner the speed of the engine may be kept constant while the power is varied over a wide range. C. R. D'E.

AUTOMOBILISM.[1]

1948. *Peugeot Petrol Delivery Van.* (Locomotion Automobile, 9. pp. 326–328, May 22, 1902.)—This vehicle has a tubular steel underframe carrying a double-cylinder horizontal internal combustion engine of 7 b.h.p. at 800 r.p.m. at its front end. The power is transmitted through a cone friction clutch and roller chain drive to the first motion shaft of the change-speed gear, which gives four forward speeds and one reverse by means of sliding spur wheels. The second motion shaft of the change gear is also the differential shaft, and from its ends the power is delivered to the rear road wheels by means of independent roller chains. The road wheels are of equal diameter front and back, and have wood spokes. Solid rubber tyres are employed. Several views of the chassis are given. C. R. D'E.

1949. *G. Richard Light Petrol Car.* (France Automobile, 7. pp. 281–288, May 3, 1902.)—The latest type of this make of petrol car is described. It has a tubular underframe spring by longitudinal plate springs from the front and rear axles. The engine, a double-cylinder vertical developing 12 b.h.p. at 1,200 r.p.m., is mounted towards the front of the frame and covered by a

[1] Electric Automobiles are described in the Section dealing with Electric Traction.

bonnet. The power is transmitted through a cone friction clutch to the spur-wheel change-speed gear, and thence, by a flexible tail-shaft and bevel drive, to the live rear axle. The change gear is so arranged that a through drive from engine to bevels is obtained on the highest speed. [See also Abstracts Nos. 714 and 1910 (1900).] C. R. D'E.

1950. *Gladiator Light Car.* **M. Gerald.** (France Automobile, 7. pp. 316–318, May 17, and p. 330, May 24, 1902.)—The underframe in this car is of wood lined with steel plate. The engine, which is of the "Aster" single- or double-cylinder type, according to the power of the car, is mounted towards the front end of the main frame, and together with the change-gear box, is attached to a subsidiary angle steel frame suspended from the wood frame. The power is transmitted through a cone friction clutch to the change-speed gear, which gives three forward speeds and one reverse, by sliding spur wheels on the Panhard system. From the second motion shaft of the change gear the power is transmitted by a bevel drive to the differential cross-shaft, and thence by independent chain drives to the rear road wheels. C. R. D'E.

1951. *Cuyer Dirigible Balloon.* **L. Fournier.** (Locomotion Automobile, 9. pp. 294–296, May 8, 1902.)—This apparatus consists of three principal parts. A platform carrying the motive mechanism, a pair of semi-cigar shaped balloons supporting the platform, and above these a large horizontal, and two smaller vertical aeroplanes. Along the longitudinal centre line of the horizontal aeroplane lies a shaft driven from the engine on the platform below, and carrying at its ends double blade propellers. In order to cause the machine to rise, the large aeroplane may be inclined slightly to the horizontal. C. R. D'E.

REFERENCES.

1952. *Feed-heaters Commercially Rated.* **H. L. Hepburn.** (Power, N.Y. 22. pp. 11–13, April, 1902.)—Principally a comparison between Poole's and Whitham's formulæ, as regards the dimensions worked out by their use. [See also Abstracts Nos. 758, 759, and 1176 (1902).] F. J. R.

1953. *Comparison of Steam and Gas Engines.* **A. Witz.** (Écl. Électr. 30. pp. 5–16, Jan. 4, and pp. 41–54, Jan. 11, 1902.)—This paper consists chiefly of a collection of valuable data regarding the efficiency of boilers, steam engines, gas producers, gas engines, and oil motors. The author considers that there is a great future for gas producers combined with gas engines. The paper is exclusively technical, and does not deal with the cost of fuel, or the commercial features of the various items. E. H. C.-H.

1954. *White Steam Carriage.* (Automobile Rev. 6. pp. 93–94, May, 1902.)—The paper gives some further details of the engine and furnace with illustrations. [See also Abstract No. 1197 (1902).] C. R. D'E.

1955. *Digest of Kerosene Burner Patents.* **F. W. Barker.** (Horseless Age, 9. pp. 650–655, May 28, 1902.)

1956. *Petroleum Vapour Burners.* **J. S. V. Bickford.** (Horseless Age, 9. pp. 632–635, May 28, 1902.)—The object of the article is to give the principles on which petroleum apparatus may be designed. C. C.

GENERAL ELECTRICAL ENGINEERING.

1957. *Tests of Accumulator Endurance.* (Résumé des Essais d'Enduranc Paris, pp. 1–16, 1902.)—These are the results of a series of tests instituted b the Ministère de la Marine. Eleven manufacturers submitted cells—all French make—and the total number tested was 21. The following procedu was adopted. The cells were all coupled in series, and after a preliminar charge, were discharged at 660 amperes, about their one-hour rate. The di charge of the whole of the cells was discontinued when any one of them fe to 1·65 volts. They were then all recharged at 330 amperes, receiving 50 pe cent. more ampere-hours than had been given out on the previous discharg Two discharges and recharges were effected every day except Sundays, whe the cells were left at rest. Any cell that from any cause whatever fell t 1·65 volts in less than half an hour, was disqualified from officially continuin to take part in the contest, and even if left in circuit, no further figures relatin to it were recorded. In this way they were one by one eliminated. At 15 discharges (which was originally intended to be the limit of the tests), 11 sti remained at work, but at 250 discharges all but 5 had been retired, and th trial was concluded, having extended from October 10, 1901, to March 1 1902. Nothing was allowed to be done to the cells at any time so long as the kept up to the prescribed standard, except to tighten up connections, or ad water or acid as their electrolyte might require. As each cell failed, it wa examined and, if necessary, taken to pieces, and particulars are given of th cause of the failure. In many cases it appears to have been due to casua short-circuits, and not to a general breakdown. Hardly any details are fur nished as to the design or construction of the different makes, or their weight Eleven cells had both positives and negatives of the pasted type; nine hac Planté type positives and pasted negatives; and one only had both positive and negatives of the Planté type. A sheet of curves is supplied showing th relative position of every cell throughout the tests. E. J. W

1958. *Submarine Telephone Cables.* **C. E. Krarup.** (Elektrotechn Zeitschr. 23. pp. 344–346, April 17, 1902.)—In this paper, some measurement of self-induction are described, which are a continuation of those made by Breisig [see Abstract No. 729 (1900)]. One feature of the present experiments is that lengths of wire or cable of 50 cm. only were employed instead of long lengths. Cables were measured in which each conductor was wound round with a separate layer of iron wire. The results showed the following: (1) Whilst in a cable without iron, or with an iron sheath common to all the conductors, the self-induction for single-conductor lines is greater than for double-conductor lines, the opposite is the case for cables with an iron sheath round each conductor. (2) The self-induction caused by the layer of iron increases in a higher proportion than the weight of the iron when the magnetic circuit is better closed. (3) The fine closely-wound wire of higher permeability is much more advantageous than bands in producing high self-induction. The results obtained are used in the well-known damping formula—

$$D = e^{\sqrt{\frac{Cp}{2}\left(\sqrt{R^2 + p^2L^2} - pL\right)}}$$

giving p (frequency) different values, so as to show the advantages of this form of cable. C. K. F.

1959. *Capacity of Polyphase Cables.* **A. della Riccia.** (Soc. Belge Élect., Bull. 19. pp. 318–326, May, 1902.)—In practice, the frequency is low enough to allow electrostatic equilibrium to set in at any instant of the cycle, and the

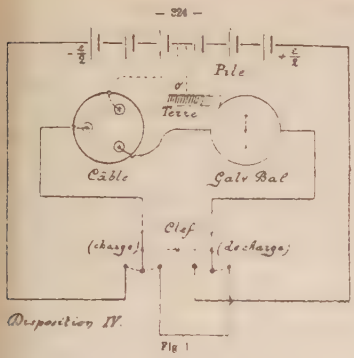


Fig 1

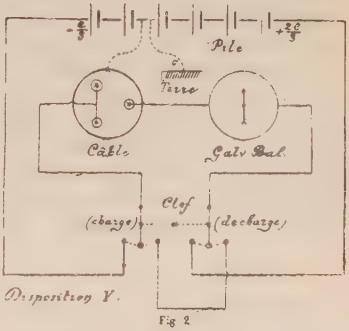


Fig 2

ordinary law of electrostatics for a number of charged bodies holds. There are eight possible tests of capacity with a three-core lead-covered cable, thus—

No.	Conductor to be connected to one Pole.	Conductor to be insulated.	Conductor to be connected to the other Pole.	Expression for the Capacity.
I.	Sheath	2 Conductors	1 Conductor	$K_1 = \frac{R^2 + RS - 2S^2}{R + S}$
II.	Sheath	1 Conductor	2 Conductors	$K_2 = 2\frac{R^2 + RS - 2S^2}{R}$
III.	Sheath	None	3 Conductors	$K_3 = P = -3Q$
IV.	1 Conductor	Sheath and 1 Conductor	1 Conductor	$K_4 = \frac{1}{2}(R - S)$
V.	1 Conductor	Sheath	2 Conductors	$K_5 = \frac{2}{3}(R - S)$
VI.	Sheath and 1 Conductor	1 Conductor	1 Conductor	$K_6 = \frac{R^2 - S^2}{R}$
VII.	Sheath and 1 Conductor	None	2 Conductors	$K_7 = 2(R + S)$
VIII.	Sheath and Conductors	None	1 Conductor	$K_8 = R$

When P, Q, R, S are constants depending on the relative radii of (i.) the conductors, (ii.) the circle round which they are placed, (iii.) the inside of the lead sheath, Test IV. gives the relation: "The nominal capacity of any one of the two conductors is double the capacity between two conductors and the third when the sheath is insulated."

Test V. gives the relation: "The nominal capacity of any one of the three conductors is equal to $1\frac{1}{2}$ times the capacity between one of the conductors and the two others, the sheath being insulated."

The figure shows the connections for the test. M. O'G.

1960. *Automatic Registering Apparatus.* **H. Fillunger.** (Zeitschr. Elektrotechn., Wien, 20. pp. 240–244; Discussion, p. 244, May 11, 1902.)—In this arrangement, which may be used as an indicator for railway signals, bells, or

rail-contacts, there is a drum which bears a recording band, and is rotated by clockwork so as to rotate once in fifteen minutes. From this drum there is driven a leading screw arranged parallel thereto and bearing a nut which moves a carriage sliding on guides. This carriage bears a number of electro-magnets, the coils of which are arranged in or connected through relays to the circuits of the apparatus to be controlled, and the spring-controlled armatures of these electromagnets actuate rods bearing different printing ends, which act on the recording-band through an ink-ribbon. By this means the time of each actuation of each apparatus is automatically recorded. A change-over switch or relay for closed circuit systems, due to E. Krassny, is also described, having a delicately balanced arm which is moved by an electromagnet when the current is interrupted in the apparatus, so as to deflect the current through a substitute resistance coil to the next signal-bell.
C. K. F.

1961. *Missouri Pacific Railroad Shops, Baring Cross, Arkansas.* (West. Electn. 30. pp. 417–419, June 14, 1902.)—These workshops are driven by 250-volt motors, including seven of 30 h.p., two of 20 h.p., and one of 3 h.p. These motors, aggregating 253 h.p., drive about 100 different tools, the total individual h.p. of which is over 500. A diagram is given showing the current taken by a 30-h.p. motor, as the various machines driven by it are started in succession.
W. H. S.

1962. *Impulse Water-Wheels.* **J. T. Farmer.** (Journal of Electricity, S.F. 12. pp. 32–39, Feb., 1902. Paper read before the Canadian Society of Engineers, Jan. 20, 1898.)—A description is given of a series of experiments on a small Pelton wheel at various heads and speeds, the greatest h.p. being about 7. The author gives a set of values for the theoretical efficiency, calculated by allowing for the loss at the jet and the inclination of the buckets to the radius of the wheel; the efficiencies realised fall short of the theoretical ones by from 15 to 25 per cent., the difference being chiefly attributable to splashing on the buckets. The actual efficiency of the wheel varied from 37·9 per cent. with a head of 235 ft., giving 1·7 h.p. at 276 r.p.m., with a nozzle 0·53 in. dia., to 70·8 per cent. with the same head, giving 6·9 h.p. at 756 r.p.m. with a nozzle 0·75 in. dia.
H. R. C.

1963. *Aluminium.* **W. M. Morrison.** (Inst. Elect. Engin., Journ. 31, pp. 400–411; Discussion, pp. 411–419, Feb., 1902.)—The theoretical voltages required for the decomposition of various aluminium compounds are:—For aluminium fluoride, 4·0 volts; oxide, 2·8 volts; chloride, 2·3 volts; sulphide, 0·9 volts. The specific gravities of the materials present in the furnace are for commercial aluminium, solid, 2·66, fused, 2·54; for commercial Greenland cryolite, solid, 2·92, fused, 2·08; and for cryolite saturated with alumina, solid, 2·90, fused, 2·35. Hence it is only just possible for the aluminium set free to sink to the bottom or kathode of the furnace. Care is required to maintain the economical temperature without altering the relationship of the specific gravities. Impurities consist entirely of iron and silicon in proportions approximately as shown:—Silicon, 0·18 per cent.; iron, 0·26 per cent. and aluminium 99·56 per cent. The production of the present year is 5,000 tons, or 100 times as much as thirteen years ago. The metals which aluminium is most likely to replace are copper and tin, the world's use of which last year was respectively 497,000 tons and 79,200 tons. The specific gravities

equivalent weights, and equivalent prices for equal volume of the common metals are shown below :—

Metal.	Specific gravity	Weight for equal volume.	Cost per ton.	Comparative cost of ingot metal for equal volume.
			£	
Aluminium	2·56	1	148	1
Zinc	7·00	2·73	17·5	0·323
Tin	7·30	2·85	115	2·21
Cast Iron	7·40	2·89	3	0·0586
Brass (50 per cent. alloy)	8·30	3·25	50	1·10
Nickel	8·50	3·32	196	4·40
Copper	8·63	3·37	66	1·51
Gun Metal.....	8·73	3·41	84	1·94
Lead	11·40	4·45	12·5	0·377

For equivalent volume aluminium weighs only 37 per cent. of the next lightest metal in common use, and that as regards cost only zinc, lead, and cast iron are lower. Its shrinkage in casting is high, as shown in the following table :—

SHRINKAGE OF CASTINGS.

Zinc	3125 inches in a foot	= 2·60	per cent.
Lead	3125 „ „	= 2·60	„
Aluminium	2031 „ „	= 1·69	„
Copper	1875 „ „	= 1·56	„
Brass	1580 „ „	= 1·32	„
Iron pipes	1250 „ „	= 1·04	„

COMPARATIVE FIGURES OF COPPER AND ALUMINIUM WIRE.

	Copper Wire.	Aluminium wire.
Specific gravity	8·93	2·65
Conductivity.....	100	61
Section for equal conductivity.....	1	1·64
Diameter „ „	1	1·28
Weight „ „	1	0·485
„ „ section	1	0·297
Tensile strength for equal section	1	0·46
„ „ „ conductivity.....	1	0·75

Out of 28 different joints for overhead wires the best is as follows :—The two ends of the wires are bent round each other, or simply butted together, they are then surrounded by a cigar-shaped mould in two halves, which are clamped together and molten aluminium run in at a hole in the top of the mould. The mould is then removed and the joint trimmed. Aluminium having a low melting-point, the metal required for this joint can easily be melted in a hand ladle on the fire of a portable forge. The 5,500 ft. of overhead line 0·38 in. in diameter have been in use for five years and have given no trouble. The author has taken the case of low-tension armoured lead-covered paper insulated cables, of the highest class, ready for laying directly in the ground, and found that with copper at 10d. per lb. aluminium wires insulated and sheathed in a similar manner of the same conductivity as copper (*i.e.*, 1·64 times the section) would have to be obtainable to equal the cost of the copper

cables, at from 14·5d. to 16·5d. per lb. for sections from 1 to 0·2 sq. in. copper. The lack of proportionality between the radial depth of insulation cables and its dielectric strength was pointed out by Swinburne, and h been very fully dealt with by Mervyn O'Gorman, who has shown conclusive that for a given voltage there is a certain section of copper which gives th cheapest cable. Above this size the increase in price is proportional to th copper. Thus in one of O'Gorman's curves it is shown that for 20,000 vol and paper insulation with lead sheathing, 0·4 sq. in. is the section of copp which gives the cheapest cable. Suppose that 0·25 sq. in. of copper be sufficient for the power to be transmitted, then, by substituting 0·4 sq. i of aluminium for the copper we get a cable which fulfils the necessar conditions, and costs from £150 to £170 less per mile than the copp cable. The following table is important :—

No. S.W.G.	Dia. in inches.	Area in square inches.	Weight in lbs. per mile.		Length in feet per lb.		Resistancy per m in ohms.	
			Alu-minium.	Copper.	Alu-minium.	Copper.	Alu-minium.	Coppe
0000000	0·500	0·196	1,194	3,981	4·42	1·33	0·353	0·2
000000	0·464	0·169	1,018	3,426	5·18	1·56	0·410	0·2
00000	0·432	0·147	891·5	2,972	5·92	1·78	0·476	0·2
0000	0·400	0·126	764·4	2,547	6·91	2·07	0·554	0·3
000	0·372	0·109	661·1	2,204	7·99	2·47	0·642	0·3
00	0·348	0·0951	578·5	1,926	9·13	2·74	0·731	0·4
0	0·324	0·0824	507·8	1,671	10·40	3·16	0·840	0·5
1	0·300	0·0707	429·9	1,433	12·28	3·68	0·980	0·5
2	0·276	0·0598	363·7	1,212	14·52	4·37	1·16	0·7
3	0·252	0·0499	304·1	1,012	17·36	5·22	1·40	0·8
4	0·232	0·0423	253·3	855·6	20·85	6·17	1·64	1·0
5	0·212	0·0353	214·7	715·7	24·59	7·38	1·97	1·2
6	0·192	0·0290	176·1	587·0	29·99	8·99	2·40	1·4
7	0·176	0·0243	148·0	493·3	35·68	10·70	2·86	1·7
8	0·160	0·0201	126·3	507·5	41·79	12·96	3·45	2·1
9	0·144	0·0163	99·1	330·5	53·26	15·98	4·28	2·6
10	0·128	0·0129	79·5	260·9	66·44	20·23	5·38	3·2
11	0·116	0·0106	63·0	214·3	83·82	24·63	6·56	4·0
12	0·104	0·00849	48·7	172·3	108·4	30·64	8·20	4·9
13	0·092	0·00665	39·6	134·8	133·2	39·17	10·5	6·3
14	0·080	0·00503	31·4	101·4	168·0	52·09	13·9	8·4
15	0·072	0·00407	24·8	81·1	211·9	65·10	17·1	10·4
16	0·064	0·00322	19·8	64·9	267·2	81·38	21·7	13·2
17	0·056	0·00246	15·7	49·9	336·9	105·9	28·2	17·2
18	0·048	0·00181	10·9	36·5	482·6	144·7	38·4	23·4
19	0·040	0·00126	7·81	25·5	675·7	207·4	55·2	33·6
20	0·036	0·00102	6·20	20·6	851·8	255·9	68·1	41·6
21	0·032	0·000804	4·92	16·4	1,074	322·3	86·3	52·6
22	0·028	0·000616	3·73	12·5	1,414	423·1	113	68·6
23	0·024	0·000452	2·74	9·16	1,929	576·4	154	93·5
24	0·022	0·000380	2·45	7·70	2,154	685·7	182	111
25	0·020	0·000314	1·94	6·36	2,716	830·2	222	135
26	0·018	0·000254	1·54	5·14	3,425	1,027	272	166
27	0·0164	0·000211	1·22	4·28	4,318	1,234	328	200
28	0·0148	0·000172	1·03	3·49	5,106	1,514	403	246
29	0·0136	0·000145	0·884	2·95	5,974	1,796	478	291
30	0·0124	0·000121	0·730	2·44	7,233	2,164	576	351

Discussion.—**W. McWhirter** said that it would be advisable to decrea the distance between the poles where aluminium lines were erected, but, the use of an aluminium alloy, the breaking weight could be increased by 33 p

cent. with slight reduction in conductivity, and considerable use would probably be made of these alloys. **H. A. Mavor** gave an example of low cost of power production at about 0·093 pence per h.p. per hour for coal, wages, oil, and stores. (See paper read to the Institution of Engineers and Shipbuilders' in Scotland on March 22, 1898.) **H. J. Bubb** said the wiring of the outside arc lighting at the Glasgow Exhibition was entirely done with bare aluminium. A drop of 10 volts was to be the maximum, the lamps being arranged ten in series across mains at 510 volts. The aluminium wire was No. 3 S.W.G. wire for long circuits, or No. 7 for short circuits. Joints were avoided where possible, and where inevitable, a butt weld was made. The flame of a blow-lamp impinged on a firebrick, the two ends of the wire to be jointed, roughly cleaned with emery paper, were brought together in the flame so that one side was heated by the flame direct and the other by the flame reflected. At the instant of semi-fusion, which was easily noticed, the ends were pressed together, and the wire steadily removed from the flame and held until the metal had completely set. The lubricant in machining aluminium was half turpentine and half water ; with this the metal could be machined with the same facility as brass. The harder alloys machined perfectly well dry. Bolts and studs should be chased, and not screwed in dies, and in cutting thread, a flow of lubricant should be kept on the work. For drawing through a die, horse-grease, tallow, or suet was recommended. **W. Murray Morrison** observed that the figure of £2 per i.h.p. per annum given by H. A. Mavor was surprisingly low, for the most economical steam engines now in use required very nearly 4 tons of coal per h.p. per annum working continuously at their highest efficiency. M. O'G.

1964. *Experimental Model Basin at Washington Navy Yard.* **J. A. McCrary.** (Elect. World and Engineer, 39. pp. 807–809, May 10, 1902.)—The basin is 40 ft. by 470 ft., and was built for determining by means of models the resistance to be overcome at the speeds at which the vessel is likely to move. A towing carriage spans the basin, running on tracks on either side, and weighing 25 tons. The motors driving the carriage have their fields constantly excited from a separate source, and their armatures supplied with current which is controlled by rheostats. The carriage tows the model through the basin, and as soon as the speed has become uniform, the recording drum of a mechanical dynamometer is thrown into action by means of a clutch, and thus the time, distance travelled, and resistance to motion of the model under the conditions of the test are recorded. A speed of 18 knots can be obtained. W. H. S.

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1965. *Accumulator "Etampé."* **J. Reyval.** (Écl. Électr. 31. pp. 168–170, May 3, 1902.)—A description of the processes of manufacturing the grids and electrodes of this cell, which are of the stamped sheet pasted type. E. J. W.

1966. *Electro-Pneumatic Control of a Sewage Reservoir.* (Electricity, N.Y. 22. pp. 288–290, May 28, 1902. From the Railway and Engineering Review.)—The Moon Island sewage reservoir in Boston is controlled by an application of the Westinghouse electro-pneumatic system, the various gates being operated at distances ranging up to 500 yards. The installation is fully described. W. H. S.

1967. *Education of the Electrical Engineer.* **W. Esty.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 771–780, May, 1902.)

GENERATORS, MOTORS, AND TRANSFORMERS.

1968. *Design of very High-Speed and very Low-Speed Machines.* **E Niethammer.** (Elektrotechn. Zeitschr. 23. pp. 437–445, May 15, 1905 Paper read before the Elektrotechn., Verein, April 25, 1902.)—The autho considers in detail the various difficulties which are encountered in designin generators and motors, both continuous and alternating, when the speed i either very high or very low. The normal range of speeds for various power is given in the following table :—

Horse-power	4	10	40	100	200	300	500	700	900	1200	1500	200
Usual Speed Limits	530 to 2200	400 to 1400	290 to 900	220 to 620	170 to 460	140 to 320	120 to 270	100 to 240	80 to 230	70 to 210	60 to 205	50 to 200

As regards the temperature limit, in the case of slow-speed machines it i desirable to use short armatures of large diameter, in order to obtain a larg cooling surface and free circulation of air ; the author emphasises the import ance of providing a sufficient number of ventilating ducts, and states tha experiments made with armatures whose ventilating ducts had been purposel stopped up showed an enormous increase in the temperature rise. Abnor mally high speeds are, of course, highly favourable both as regards heatin and efficiency, and in this respect present no difficulties. As a result o measurements made on hundreds of machines, the author states that if a attempt be made to calculate the temperature rise t from a formula of th type $t = Cw/s$, where w = total watts dissipated, and s = total radiatin surface, then the value of the coefficient C varies from 200 to 1,400 *in the cas of open-type machines,* rendering any calculation of the probable rise quit hopeless ; but in the case of *enclosed* motors, the range of variation of C i only from 600 to 900, and reliable results may be obtained. The considera tion of the temperature limit leads the author to institute a compariso between a 200-h.p. continuous-current motor and a three-phase induction moto of the same power, the efficiency at full load being in each case 94 per cen The following table gives the distribution of losses at full load and at starting the starting torque being taken as three times the full-load running torque :—

	Cont. Current Motor running at 200 h.p., in h.p.	Cont. Current Motor at starting with 3-fold torque, in h.p.	3-Phase Induction Motor running at 200 h.p. in h.p.	3-Phase Motor at starting with 3-fold torque in h.p.
Armature copper (rotor) loss	3½	22	3½	43
Field copper (stator) loss	3½	22	3½	12
Iron loss	5	0	5	43
Total loss.....	12	44	12	98

Even in the case of the continuous-current motor there is great difficulty in keeping the temperature rise within reasonable limits when starting is frequent; the difficulty in the case of the three-phase motor is, as the table shows, enormously greater. According to the author, this shows the soundness of the system of rotary converter working advocated by American engineers, and the wisdom of the decision arrived at in connection with the Inner Circle line. The problem of sparkless commutation in relation to speed is next dealt with. The author advocates the use of lap windings with equalising rings in preference to multiple wave windings. The importance of the "reactance voltage" is pointed out, and detailed formulæ given for calculating it in various cases. Abnormally slow-speed machines present no difficulty as regards sparkless commutation, whereas abnormally high-speed machines are extremely difficult to design satisfactorily from this point of view. A purely mechanical difficulty arises in the case of abnormally high-speed machines (such as steam turbine-driven generators), on account of the fact that when the maximum permissible diameters of armature and commutator (determined by the greatest safe centrifugal stress) have been reached, an increase of output can only be obtained by increasing the length of the armature, and a point is reached beyond which the armature core stampings cannot be satisfactorily held in place on account of the excessive length of the clamping bolts. Various other mechanical difficulties, with special reference to three-phase generators and induction motors, are finally dealt with. A. H.

1969. *American Practice in Dynamo Design.* **T. Square.** (Elect. Engin. 29. pp. 734–736, May 23, 1902.)—The author gives the flux densities in American machines as follows: Core, 13,000 to 18,000 lines per sq. cm.; teeth, 18,000 to 21,000 lines per sq. cm.; poles, 13,000 to 16,000 lines per sq. cm.; yoke, 13,000 to 16,000 for cast steel, 6,000 to 8,000 for cast iron. The Stanley Electric Co. have devised a method of covering copper wire with boiled linseed oil, which they say is quite as good as double cotton covering, and takes up less space. R. B. R

1970. *Heyland's Compensated Motor.* **M. Breslauer.** (Zeitschr. Elektrotechn., Wien, 20. pp. 193–196; Discussion, p. 196, April 20, 1902.)—The paper gives a popular description of the principles of Heyland's motor, with remarks as to its use as an induction generator. In an actual case mentioned, the current taken by a motor, when running light, was reduced from 15 to 3 amperes by the compensating winding. In a footnote, the author states that a 500-kw. induction generator with Heyland compounding had been tested. The compounding was perfect with power-factors varying from 0 to 1. [See also Abstracts Nos. 2475 (1901), 199, 567, and 1237 (1902).] A. E. L.

1971. *Automatic Transformer Switch.* **D. Jakobovits.** (Zeitschr. Elektrotechn., Wien, 20. p. 181, April 13, 1902.)—The author describes an automatic switch for cutting out transformers when the secondary circuit is opened, and switching them in again as soon as the circuit is closed. A small auxiliary transformer is used, connected through a third wire with one side of double pole switches on the various current- sing apparatus. On account of the need for this third wire, it is only suitable in special cases, such as groups of motors, &c. A. E. L.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

1972. *Fault-Finding on Cable Networks.* **P. Charpentier.** (Écl. Élect. 29. pp. 196–205, Nov. 9, 1901.)—The author's extension of the loop method which was given in Abstract No. 1013 (1902) is summarised. The difficulty with loop methods arises from the high conductivity of the conductors, and the errors introduced by the resistance of joints. The method of Agthe described in C. H. Beranger's book, "Essais et Verifications des Canalisations Electriques," utilises a pilot wire of opposite polarity to the main conductors. An earth on the main cable induces a short-circuit between this pilot wire and its main cable, and suitable fuses on the pilot wire enable the faulty section to be found. A fault may exist upon a cable long before the pilot wire indicates it; this is a drawback to the system. The author suggests a more elaborate system of pilot wires on which to use a loop test. M. O'C.

1973. *Continuous-Current Mains.* **J. C. A. Ward.** (Inst. Elect. Engin. Journ. 31. pp. 852–878, April, 1902.) (Discussion.) [See Abstract No. 1623 (1902).]—**A. Jamieson** recommended a compressed hard compound of mica tailings of a similar nature to that of the "Brooklyn" and "Globe" insulators for insulating cable ends in preference to corrugated ebonite. For preventing osmosis nothing surpasses several coats of the best elastic varnish. **C. D. Burnet** said that in Carlisle the Corporation contracted to supply current for traction. The negative bar was earthed at the station, as also was the middle wire of the lighting system, and here he feared that the breaking of a bond in the rails of the tramway would be deleterious to the cables if the lead sheath were continuous throughout. By cutting the lead of a long cable at intervals an opposing e.m.f. was set up between the lengths of lead, and the sum of these would be in proportion to the number of interruptions in the lead with the result that the current would be more likely to travel along some conductor other than the cable sheath, whereas one faulty bond in a continuous lead sheath would probably burn out. **G. K. Chambers** said that electrolysis was cured by bonding the lead and earthing it. The difficulties of putting down earth-plates were small, except when the plate had to carry large currents, because the current passing from the plate to the soil tended to dry out the moisture and insulate the earth-plate. In the case of the lead sheathing the currents were either small or only temporary. He preferred fusing distributors at the feeding-points, and dividing up the network into a number of sections, each of which was fed by a feeder, and connecting those points where the sections met through light fuses. The cost of the author's box must be high. He would be far better advised to spend the money on overground section pillars. **C. A. Henderson.**—It was cheaper to lay four extra crossings to one large 8-way box rather than to have four 4-way boxes at the four corners of two intersecting streets. The author had omitted one of the most serious faults of strained copper strip, viz., the phenomenon of "jumping" when heavily loaded suddenly by a fault. He had seen on several occasions strained strip which has been feeding a fault "jump" so badly as to release itself from the strain insulators and fall to the bottom of the culvert. **F. A. Newington.**—Ordinary short-circuits on distributing mains cleared them

selves without doing much damage. A short-circuit on a feeder necessitated that feeder being switched off at the generating station, and then the fuses in the distributing mains acted, cutting off the supply in that district until the feeder was re-connected. The arrangement shown by the author did not prevent a district being cut off if a feeder broke down, therefore feeder fuses did not appear to be of much use. A disadvantage of bare strip was the great force exerted by attraction between two conductors of different polarity, in the event of a sudden rush of current. With two conductors placed 3 in. apart, if a short-circuit occurred, of, say, 5,000 amperes (which is a moderate estimate for the first second or so), there would be a pull of about 200 lbs. on each insulator. **W. A. Chamen** said that an advantage of copper strip was that one could get a real short-circuit, whereas with concentric cable a real short-circuit seldom occurred. Arcs would form and go on burning for some time before enough current would pass to blow the fuses. In the early days of the Kensington and Knightsbridge Co. lead-sheathed cables were used to connect consumers, and it was found that they were always going wrong in the walls. Miller discovered that the current was leaking over the ends on the lead passing along to the walls and there getting to earth and corroding the cable. A different trouble was that the lead sheathing of the cable came in contact with the circuit through some accident, and if the sheathing was insulated in bitumen the current might have to go along until it could find a place weak enough to allow it to jump to earth ; and if in cast-iron troughs, it would burn holes in the lead at these places. That was the trouble in Glasgow. They had had to give up lead-wiped joints and their joints now were all made with compound. In his idea feeders ought to be coupled to a common network by means of non-return cut-outs at the feeder-points. It was, however, troublesome, as a manhole was not a good place for an automatic switch. **M. B. Field** wrote that he was using unusually heavy lead sheath on cables, the thickness being $\frac{3}{16}$ in. The coppers were jointed by means of copper sleeves slipped over the butted ends of the cores and soldered. This saved much time in jointing. **S. Mavor** said that indiarubber insulation was out of the question for large cables owing to its cost and non-durability. The better policy was to adopt a type which would be permanently durable. O'Gorman showed him a short time ago a very interesting cable devised for high-tension work. It was insulated in several layers. The inner layer was impregnated with an oil of relatively great capacity, and each layer successively had a smaller capacity, the result being that the stress was uniformly distributed, the advantage being analogous to that of a wire-wound gun. The advantages of triple concentric cables were : they were self-contained ; there were fewer cables to handle ; the cost was less ; the space required was less, and therefore there was less liability to damage ; there was less bonding required, and, if well done, the troubles from electrolysis would not exist ; they were self-testing in a way that separate cables were not. **J. Brown** used feeders and mains of three separate armoured cables laid direct in the ground. Most of the faults had been traced to ends in manhole boxes, and were, almost without exception, on the negative conductor. **J. M. Munro** said it would be interesting to know how the author first became convinced that for the protection of lead tubes a cheap pitch compound would serve for filling troughs as well as the more expensive bitumen so long considered necessary. **Ward** did not agree with the insulating of the lead sheath. Although Burnet might obtain an opposing e.m.f. between lengths of sheath by insulating the sheathings on either side of cast-iron joint-boxes, this ingenious idea would only prevent stray currents from outside sources travelling along the lead ; but

these currents were not the only troubles to be contended with. Some en neers not only fused all distributors at the feeding-points, but also the feede at the distributor bus-bar. This was not done in Glasgow, the feeder bei connected by a solid link to the bus-bar. The reason was that the feed must have not only a safe margin over the normal load on the bus-bar, b also over any extra load when a distributor fuse blew in a faulty section. the event of a fault on the feeder it was a very remote chance that the fu between the feeder and the bus-bar would blow. If a fault occurred any feeders in Glasgow they relied upon the station fuses blowing, and al those on any of the distributors connecting the faulty feeder with a good on A system of single conductors with an insulating outer sheathing, each co ductor being laid in a separate channel of insulating material, was lea likely to require fusing at feeding-points, for it was exceptional for hea leaks to be possible, and faults might quite well burn themselves clear. B in a concentric lead-covered system, arcing was set up between all conducto and would burn back to the nearest joint-box. The time and material co in manufacturing the 4-way box used in Glasgow was—

	£	s.	d.
Cast-iron box complete, with all cast-iron fittings.....	8	10	0
Fuse gear, including all gun-metal fittings, and ends for four 0·25 triple concentric cables	6	0	0
Manhole cover (uncaulked, but watertight).....	2	0	0
Total complete	£16	10	0

The cost of a T-box for taking a concentric 0·06 off a 0·15 triple concentr cable was 11s. 6d. The cost of two single T-boxes for a two-wire branch the same sizes of cables was 14s. 6d. and two boxes took up more space th one. The best coal tar pitch mixed with shale oil to soften it was quite suitable for the solid system as the unrefined bitumen, while being one-four the price. Three years' experience in Glasgow had not shown the slighte deterioration of the sheathing which could be attributed to the pitch, thou Trinidad bitumen was far more adhesive to the lead. The objections pouring molten lead into the pocket of a joint-box and around the le sheathing were : (1) The lead poured in would contract, and if metallical adhering to the sheathing would not do so to the cast-iron joint-box, and t joint would not be watertight, neither would a good bond be effected. (The body of lead poured in would concentrate so much heat round t sheathing that it would partially destroy it. M. O'

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1974. *Eastern Electric Light Co., Paris.* **H. Martin.** (Génie Civil, 4 pp. 17–23, May 10, 1902.)—This company carries on electric lighting in t eastern suburbs of Paris, and has built a central station at Alfortville, when current is supplied at 5,000 volts to various substations. The station Alfortville is on the banks of the Seine, and is built on piles. It contains boilers, each giving 3,120 kg. of superheated steam per hour, the gases bei passed through an economiser of 228 tubes, and into a chimney 50 m. hi and 2·5 m. in diameter. The engines are of the horizontal compound tand type by Carel of Ghent ; they give 700 b.h.p. at a speed of 100 r.p.m., t cylinders being steam-jacketed. The three-phase Alioth alternators g

540 kw. at 5,250 volts, the power-factor being taken as 0·75, and the frequency 50. The diameter of the rotating portion is 5·1 m., and its weight is 38 tons. The excitation of the machines is effected by dynamos driven by three-phase motors; these dynamos also light the building and drive various pumps, the current being supplied at 125 volts. There is also a battery of accumulators giving 40 amperes for 10 hours. The bus-bars are constructed on the ring principle, and various removable connections render it possible to isolate a section for the purpose of repairs. The substation at Ivry replaces a station which has hitherto generated continuous current, and the municipal authorities required the supply to be continued on the same principles. The frequency of 50 being considered too high for rotary converters, asynchronous motor-generators were adopted. Three of the machines consist of a motor, taking current at 5,000 volts, coupled to a dynamo giving 100 kw. at 250 volts and also to a small booster for charging the accumulators. The fourth group consists of a motor coupled to two dynamos, each giving 100 kw. at 250 volts. Current is supplied to consumers on the three-wire system, with a pressure of 500 volts between the outer conductors. The batteries in this station give 70 amperes for 5 hours. The substation at St. Maur replaces one which has generated alternate current at 3,000 volts; this pressure has been maintained, transformers being installed to change from 5,000 to 3,000 volts. This pressure is then transformed to 110 volts for purposes of distribution. Other districts are supplied with current at 125 volts, furnished by transformers in substations. The article contains drawings of machinery, switchboards, &c.

W. H. S.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

1975. *Energy and Motor Capacity in Railway Operation.* **C. T. Hutchinson.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 117–152, Feb., 1902.)—The author works out the solution of various electric railway problems (for suburban lines), chiefly analytically. The case is taken of uniform acceleration followed by coasting and braking, the complete solution of which is reduced to three equations. All the terms in these equations are functions of the three accelerations, except one which is the average velocity divided by the total time from start to rest between two stations; this term the author calls the "through acceleration." The paper does not lend itself to abstracting, as it consists largely of equations illustrated by curves of particular cases. After giving the general equations the author passes on to schedule speed and motor curves. He finds that the values of torque and speed in terms of input are nearly the same for motors of different size and make. Then follow expressions and curves giving power, energy and distance in terms of time. The author finally considers motor capacity and heat losses. It is assumed that the motor operates at the rated capacity on a one-hour basis (heating to 75° C.) at the moment when all resistance is cut out and the motor begins to run on the motor curve. The capacity of the equipment (commutation being the limit) is found to be as follows :—

Acceleration in miles per hour per sec.....	0·5	1	1·5	2	3
Capacity in kw. per ton	14·9	25·5	36·3	47	68

Actual measurements show that the average core loss in tramway motors at the rated output is 3·4 per cent. and the average copper loss 8·6 per cent.

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

Approximately a motor will carry its rated output for 25 per cent. of the tota time. The above total loss is 12 per cent.; hence a motor can dissipat continuously 3 per cent. of its rated capacity. If this is regarded as a lim in addition to commutation then the figures given above for capacity c motor equipment become modified to some extent. High acceleratio means a great increase in weight of motor equipment, and this again in fluences the energy required. The capacity of the equipment is proportiona to the square root of the distance between stations. The author conclude that the acceleration which gives the lowest motor capacity is the mos economical, the energy being less for the lower accelerations. He consider that the proposed express service of the New York Rapid Transit Line is a impossibility, the weight of the motors being prohibitive. W. R. C

1976. *Selection of Electric Motors for Railway Service.* **W. B. Potter** (Amer. Inst. Elect. Engin., Trans. 19. pp. 157–165, Feb., 1902.)—The autho criticises the average figures taken for losses given in the preceding Abstrac pointing out that the limits vary very much in practice. Owing to th complex character of the losses, motors cannot be well compared by runnin for an hour on an arbitrary voltage. For a given service the speed curve should be first determined and thence the losses from the resistance an core loss curves. The most accurate method is, of course, to mount th motors on a car and to run them under the required conditions. A table given showing the capacity for a safe temperature of a 38-h.p. motor wit different stops per mile, gear ratio and tons per motor. W. R. C

1977. *Electric Traction.* **P. Dawson.** (Elect. Rev. 50. pp. 788–78 May 9; 833–834, May 16; and pp. 874–875, May 23, 1902. Paper rea at Northampton Town Hall.)—The author gives figures which may b used for estimating purposes in connection with tramway work. He als gives tables showing the amount of capital already spent on the variou tramways in England, and the financial and other results obtained in twelv of the largest towns. Another table gives figures showing the capacity o plant installed in various towns to supply the tramways, and other usef particulars are also given. W. H.

1978. *Acceleration on the Liverpool Overhead Railway.* (Electrician, 4 pp. 373–375, June 27, 1902.)—An important change of equipment ha been made so as to increase the acceleration on the line. With the ol system, the entire distance of 6½ miles was run in 32 minutes includin 16 stops, or practically at a scheduled speed of 12½ miles an hou This requires a minimum of 14 trains running at five-minute interva to cope with the traffic. The new equipment is guaranteed to ru the whole distance, including the 16 stops each of 12 seconds, in 20 minutes, which is equivalent to a scheduled speed of 19 miles an hou The weight of the train, including 154 passengers, is 55 tons. Tests sho that the journey is easily made under 20½ minutes. Curves are give which show that the acceleration reached 4·2 ft. per second per second, nearly 3 miles per hour per second, thus enabling the train to cover th 2,110 ft. between the stations in little over one minute, including starting an stopping. This rapid acceleration is attributed to the excellent commutatio of the motors, which will not spark when carrying 400 amperes, which is fo times their normal current. The curves also show that the retardation of th brakes is satisfactory. The negative acceleration reached 4·7 ft. per seco

per second. The frequent stopping of trains running at high-schedule speed will consume from 120 to 150 watts per ton-mile. If the stops are far apart, the watts required are from 90–100 per ton-mile. In the experiments recorded, the watts consumed were 137 per ton-mile, which is equivalent to about 6·35 kw. per train-mile.

The following table shows the comparison between the old and the new systems :—

	Old System.	New System.
Mean speed	12½ miles = 20 km.	19⅓ miles = 31 km.
Number of stops	16	16
Mean time at stations	11 seconds	11 seconds
Mean distance between stations	729 yds. = 666 m.	729 yds.
Watts per ton-mile	110	137
Acceleration	1·6 ft. = 0·44 m. per sec. per sec.	3 ft. = 0·91 m. per sec. per sec.
Retardation	3 ft. = 0·91 m. per sec. per sec.	4·8 ft. = 1·26 m. per sec. per sec.

Each of the new trains is fitted with four 100-h.p. railway motors designed by S. H. Short, and built at the works of the English Manufacturing Company at Preston. The efficiency at full load is 93 per cent. The temp. rise after one hour's full load is as follows :—
Commutator, 55° C. ; armature, 39° C. ; fields, 57° C. ; pinion bearing, 14° C. ; commutator bearing, 9° C. The complete motor weighs 4,387 lbs., made up as follows :—Motor, 3,945 lbs. ; gear, 260 lbs. ; housing, 140 lbs. ; links, 40 lbs. ; and key, 2 lbs.

Twelve trains of the new type will replace fourteen of the old type. With the previous equipment, the trains ran 144 train-miles per hour, while in the new method they will run 216 train-miles per hour. The five-minute heading between the old trains will be reduced to 3½ minutes. This means that the journey will be made in two-thirds of the time previously taken. Numbers are given contrasting Liverpool and other electric lines :—

	Miles per hour, including stops.
Liverpool Overhead Railway	19
Manhattan Elevated, New York	13·5
Metropolitan „ „	14·1
South Side „ Chicago	14·6
Lake Side „ „	12·5
City and South London	12·5
Central London	14

[See also Abstracts Nos. 601 and 1597 (1900), 2043 (1901).] W. W. H. G.

1979. *Electric Traction on Steam Railways in Italy.* **C. A. Carus-Wilson.** (Inst. Elect. Engin., Journ. 31. pp. 1091-1110 ; Discussion, pp. 1110–1120, June, 1902.)—The author describes the work which has been done by the Adriatic and Mediterranean Railway Companies in equipping portions of their lines electrically. On the former railway the portion from Lecco to Colico, and thence to Sondrio and Chiavenna, is worked on the three-phase system with polyphase motors at 3,000 volts, there being two trolley lines with the rails as third conductor. The system will be extended to Milan. The hydraulic power-house is at Morbegno. The Mediterranean

Railway Company has electrically equipped the line from Milan to Gallara and thence to Varese, Porto Ceresio, Laveno, and Arona. The power-hou at Tornavento is not yet complete, steam generating plant being us temporarily. This system is worked by rotary converters supplying curre at 650 volts. [See also Abstracts Nos. 1377 (1900) and 2294 (1901).] T following table compares the weight, power, and dimensions of the polypha motor cars on the Lecco line with the direct-current motor cars on the Var line :—

	Total Weight Empty.	Length of Frames.	Seats.	No. of Motors.	Maximum h.p. of each.	Total Maximum H.P.	Weight of Four Motors.	Fu Spe on Lev
	Tons.	Feet.					Tons.	M.P
Varese	40	52	63	4	150	600	10	56
Lecco	53	57	56	4	{ 2 of 150 } { 2 of 75 }	300	15·2	37

The trains consist of two carriages, and run at much more frequent interv than was thought desirable under the steam system. This increase in t service, together with a reduction of fares, is expected to result in a mu larger traffic. The extent to which the traffic was likely to be increased w experimentally tested on the line from Bologna to St. Felice with cars fitt with accumulators. The speed and the frequency of the trains were bo doubled, and the fares reduced to 40 per cent. of their original amount. T result has been that the passenger traffic has increased fivefold and t receipts have been doubled. The author compares the conditions of runni an electric service in England and Italy, and, assuming that twenty-eig short trains are run each way per day over a certain line instead of eig longer ones, he calculates that the working expenses would be increas by £360 per mile per annum. This, together with interest on the cost construction, which is taken at £8,000 per mile, amounts to an increase £640 per mile per annum. On the Great Northern Railway the passeng receipts are 43d. per train-mile, and the passenger traffic would have increase 61 per cent., if the fares were unaltered, in order to meet t increased expenses. The author's contention is that electricity will not h the railways by reducing their expenses, but by enabling them to of increased travelling facilities at a figure impossible with steam traction. T paper contains a large number of figures dealing with running expens receipts and expenses per mile of line in England and Italy, fares in Ita and the cost of working steam and electric trains in England and Italy.

W. H.

1980. *Edmondson's Automatic Locking Signals.* (Elect. Engin. 29. pp. 90 907, June 27, 1902.)—To provide a block system on electric tramways a railways, a short brass bar held by springs fixed near to, but insulated fr the ear or bracket, is caused to make contact with the trolley head as the travels. Such a contact operates a relay switch contained, with the necessa iron cores and solenoids, in a box attached to the pole, alongside of which a the semaphore arm and bull's-eye. At the entrance to a block section (protect by one semaphore at each end), the first contact puts the distant arm

"Danger," the second contact, just ahead of the first, puts the near arm to "Danger," and thus the section is blocked except for the car then travelling upon it. This car, upon reaching the end of this section, is caused, by means of its trolley head, and by means of appropriate circuits, to lower the signal at entrance to this section, and thus to clear it for another car. Exactly similar arrangements exist for a car coming in the opposite direction on the same pair of rails from a passing-place. Matters are so contrived that when both cars simultaneously endeavour to enter one and the same section each home signal goes to "Danger" and signifies the positions of the cars to the driver. The car that has to back out would then automatically release the semaphore opposing the movement of the other car, and the latter would proceed as usual. The mechanism and the lamps are run off the trolley-wire current. E. O. W.

1981. *Tram-Rail Drilling Machine.* (Engineer, 93. p. 430, May 2, 1902.)—A machine is here described which was made by Buckton for the North-Eastern Steel Co. It has four spindles and drills four holes simultaneously. In drilling fishplate bolt-holes, two are drilled from one side and two from the other, and in this way the pressure is equalised. The drills are formed from rectangular steel, sharpened at the ends and the sides; in this way, when the drills are through the rail, it can be advanced longitudinally against the sides of the drills, and the holes are made oval. The machines are used in pairs, and the two drill holes at opposite ends of the rail simultaneously. W. H. S.

1982. *American Tramway Practice.* **J. B. Hamilton.** (Tram. Rly. World, 12. pp. 88–90, July 5, 1902. Paper read before the Association of Municipal Tramway Managers, July, 1902.) —*Track Maintenance.*—The author contrasts the general state of American roads with English. *Cast Welded Joints.*—After two years' wear these presented a good surface appearance, but American opinions differ as to this practice. *Electrically Welded Joints.*—In Buffalo there are about 30,000 of this type on about 109 miles of track. The cost per joint is about £1, and this method has given great satisfaction. The disadvantages are the time the tracks are out of service during reconstruction or welding. An electric welding plant occupies the track night and day during the welding process. *Continuous Rail Joints* are largely used for repair work. *Care of Car Equipment.*—Great diversity of practice. In some places cars are inspected every three or four days, and overhauled every two months, whilst in other places it is considered sufficient to inspect them once a week, and to overhaul them only when armature bearings need renewing. Generally speaking, one man attends to seven cars. Except for trifling repairs, all cars are sent from the various depôts to a central repairing works. In most cities the electrical repair work is done on "piece," and in Brooklyn the overhauling of the trucks is also done on stated terms. The following are the Brooklyn rates: Overhauling trucks, about $2; overhauling motors, $1; replacing wheels, 50 c.; replacing pony wheels of double truck, 30 c.; replacing brake beams, 40 c.; replacing brake shoes, 60 c. Closer supervision than in this country is, of course, necessary. *Power Stations.*—Except on the New York Metropolitan Railway, where three-phase current is generated, the principal cities generate continuous current, but the intention is to adopt three-phase for future work. The method of "transportation," that is, the routine of the motor-man and conductor's duties, is touched upon. The maximum speeds are not greater in America than here, but the average speed is higher, owing to more rapid acceleration. F. B.

ELECTRIC LAMPS AND LIGHTING.

1983. *220-Volt Lamps.* **F. W. C. Bailey.** (West. Electn. 30. p. 425 Discussion, pp. 425–426, June 14, 1902. Abstract of paper read before th National Electric Light Association at Cincinnati, Ohio, May 22, 1902.)—Th author gives the results of his tests on 16-c.p. lamps at 220 volts, at least 50 each make being examined for the purpose of forming an average. Thre fourths of the makers used the double-oval shape of filament. The followin table summarises the results :—

Efficiency Table for Horizontal and Spherical Candle-power.

Lot.	Type of Filament.	Average Watts per Initial Mean Spherical Candle-power.	Average Watts per Initial Mean Horizontal Candle-power.	Average Watts per Mean Spherical Candle-power during Useful Life.	Average Watts per Mean Horizontal Candle-power during Useful Life.	Average Watts per Mean Spherical Candle-power during Test of 1,500 Hours.	Average Watts per Mean Horizontal Candle-power during Test of 1,500 Hours
A	Double oval	4·88	4	5 37	4·40	6 09	4 99
B	„ „	4·73	3·89	5·45	4·5	6·99	5·77
C	„ „	4·66	3·83	5·15	4·23	5·94	4·89
D	„ „	4·87	4·04	5·23	4·34	6·15	5·10
E	„ „	4·16	3·39	4·61	3·76	6·21	5·06
F	Three-coil ellip. spiral ...	5·52	5·3	6 12	5·88	6·33	6·08
G	Two loops in series	4·98	4	5·47	4·39	6·23	5
H	Double oval	5·42	4·45	5 95	4·89	6·2	5·09
I	„ „	4 81	3·98	4·96	4·10	6·28	5·20
J	„ „	4·53	3 67	5·06	4·10	5·96	4·83
K	„ „	4·77	4·05	5·28	4·88	6·13	5·20
L	„ „	5 00	4·07	5·42	4·5	7·18	5·85
M	Two ovals in series	4·87	4·06	5·67	4·73	6·27	5·23
N	Two-coil spiral in series	3·99	3·36	4·38	3·73	5·1	4·38

The report of the paper is much condensed ; but it would appear that th useful life of lot N was considered to be 467 hours, which is as good as tha of a 100-volt lamp taking initially 3·1 watts per c.p. Reference is made to preceding communication to the Association by F. W. Willcox, who als explained in the discussion the method used for determining the figure relating to mean spherical candle-power. W. H.

REFERENCE.

1984. *Graphical Solution of Network Problems.* **B. Soschinski.** (Elektrotechn Zeitschr. 23. pp. 359–362, April 24, 1902.)—In the graphical representation of th fall of potential along a distributor, it is more convenient to use for abscissæ actu distances, and not mere resistances. The author investigates the modification of th diagram due to this change, assuming a distributor of varying cross-section, an considering a number of standard cases. The paper does not admit of a usefu Abstract. A. H

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

NOVEMBER 1902.

GENERAL PHYSICS.

1985. *The Gravitation Constant.* **G. K. Burgess.** (Phys. Rev. 14. pp. 257–264, May–June, 1902.)—The author summarises the experimental results for the earth's mean density, and deduces the most probable value by the method of least squares. The result is for the earth's mean density $5{\cdot}5247 \pm 0{\cdot}0013$. The corresponding value of the absolute gravitation constant is $(666{\cdot}07 \pm 0{\cdot}16) \times 10^{-10}$. It would seem desirable to make a new experimental determination of the density by Wilsing's method. W. S.

1986. *Measurement of Minute Masses.* **E. Salvioni.** (N. Cimento, 3. pp. 386–389, May, 1902.)—The author has devised and accurately examined a microbalance, which consists of a thin thread or very thin ribbon of glass or other material, fixed at one end and placed in a closed case; the case also contains a number of small weights (the larger of platinum wire, the smaller of silk thread), which, with the aid of a handle, can be placed on the flexible thread or ribbon. The flexure of the thread when loaded is observed by means of an ocular micrometer, and, as verified by the author for his instrument, is proportional to the weight which produces it; a conveniently placed spider thread serves as a sight-line for the measurement of the displacements. A glass thread 10 cm. long, and one to two-tenths of a millimetre in diameter will support by flexure a weight of more than 100 mgr., and, if provided with an optical arrangement which magnifies one hundred times, will serve to weigh to one-thousandth of a milligram. To avoid the inconvenience caused by subsequent elasticity, the balance is provided with an arrestment which enables the flexure to be maintained after unloading. The author finds that the loss of weight of musk by volatilisation is clearly demonstrated by this instrument. The loss is proportional to the time. D. H. J.

1987. *Stability of a Thin Hollow Cylinder of Revolution acting as a Strut.* **A. Gros.** (Comptes Rendus, 134. pp. 1041–1043, May 5, 1902.)—The question considered is the following: Given a hollow cylinder of thickness t, small compared to the radius r, subject to given longitudinal thrust uniformly distributed, to determine the minimum thickness in order that the cylinder may completely regain its original form after strain. The author divides the

cylinder into prismatic elements by means of very close meridian planes, and supposes a deformation such that the solid remains a solid of revolution. Then by symmetry every prismatic element is in the same condition. Hence if we neglect transversal elasticity, *i.e.*, suppose the cylinder formed by mere juxtaposition of the elementary prisms, Euler's formula for a long rod with ends free reduces to $p = \pi^2 E l^3/48 l^2$, where $2l$ is the length of the cylinder, E its modulus of elasticity parallel to the generators, and p the thrust per unit length of the circumference. This condition ensures the elastic equilibrium of each elementary prism supposed isolated, and *a fortiori* that of the real cylinder in which they are connected. The condition is therefore *sufficient, but not necessary* for elastic equilibrium of the cylinder with ends free. By considering the transversal elasticity E′, and using the elementary theory of plane flexure, the author finds for the stability of the elementary prisms, and consequently of the whole cylinder, the *sufficient but not necessary* condition $p = t^2 \sqrt{EE'}/r\sqrt{3}$. He thus finds two completely independent conditions, either of which ensures stability. In practice of course a factor of safety must be adopted, and in view of the small thickness the value of t should be modified, *e.g.*, in calculating the greatest load for a given thickness it is prudent to substitute a quantity $t - t'$ for t. The modification of the formulæ to suit the case of constrained ends is obvious. W. S.

1988. *Thin Floating Cylinders.* **T. Alexander.** (Nature, 66. pp. 6–7, May 1, 1902.)—The author pointed out [see Nature, 55. p. 366, 1897] that a thin cylindrical floating shell is in equilibrium under the actions of its own weight and the external fluid load, the shell having its axis horizontal, and just touching the surface or else completely submerged. He now shows that "polygonal cylinders of uniform plates freely hinged at their edges and displacing their own weight of fluid and lying horizontally are also in equilibrium, provided the polygon be regular." The ends are supposed closed by smooth plates having the same density as the fluid ; they exclude the fluid but allow free motion of the hinged sides. W. S.

1989. *Elasticity and Viscosity of Ice.* **H. Hess.** (Ann. d. Physik, 8. 2. pp. 405–431, May, 1902.)—The author investigates the viscosity of ice by observing the rate of deformation of rods of the substance loaded in the centre, and studies the mode of its dependence on the kind of ice, the magnitude of the force acting, its direction with respect to the crystalline axis, and the time. In all cases if the force be constant the viscosity decreases with the time ; for the relation of the viscosity to the other quantities involved reference must be made to the original paper. With a view to the bearing of the matter on glacier motion, he investigated a mixture of ice and rough particles of sand, cemented together by allowing the interstices to fill with water and then freezing ; for such a mixture the viscosity is, *ceteris paribus*, about ten times as great as for pure ice. He used also a mixture composed of compressed ice, dust, snow, and other substances in layers. For the Young's modulus he finds for all kinds of ice the value $2{\cdot}76 \times 10^{10}$ c.g.s., which agrees with Reusch's value obtained by a different method. The author has also experimented on the velocity of efflux of ice from a cylinder when subjected to pressure ; he finds an increase in the velocity with the time, the pressure being constant. Finally he considers his results with reference to glacier motion. W. S.

1990. *Compressible Viscous Fluids.* **P. Duhem.** (Comptes Rendus, 134. pp. 1088–1090, May 12, 1902.)—The author defines a fluid as a body, each element of which is in a state completely defined by the temperature T and a single normal variable, the density ρ. Hence within the fluid the virtual work of viscosity (dv denoting the element of volume) is—

$$d\bar{\omega} = \int f(\rho, T)\frac{d\rho}{dt}\cdot\delta\rho\, dv.$$

For an incompressible fluid this is identically zero, whence *if a body is rigorously fluid and rigorously incompressible, it must be considered devoid of viscosity.* All viscous fluids are compressible, and the properties of such fluids are derived from the above equation. The author shows that the equations of motion of a viscous fluid are the same as the ordinary Eulerian equations, with the "fictive" pressure P substituted for the actual pressure Π; but the equation of compression and dilatation, which was $\Pi - \rho^2\frac{\partial\zeta(\rho,T)}{d\rho} = 0$, becomes—

$$P - \rho^2\frac{\partial\zeta(\rho, T)}{d\rho} - \frac{\lambda(\rho, T)}{\rho}\frac{d\rho}{dt} = 0;$$

thus the laws of motion of a viscous fluid differ from those of a non-viscous only in that *there is no longer a relation in finite terms between the pressure, temperature, and density, such relation being replaced by a differential equation giving dp/dt in terms of ρ, T, P.* He points out also that for a compressible perfect fluid, at a point where the pressure and temperature are P and T, the density ρ has the same value ρ_0 as if the fluid were in equilibrium under that pressure and at that temperature; while for a viscous fluid in motion ρ at each point varies in such a sense as to approach ρ_0. In a *slightly* viscous fluid, where the velocity varies but little from point to point, ρ is very nearly equal to ρ_0, and so we see how a perfect fluid is the limiting form of a fluid slightly viscous.

W. S.

1991. *Viscosity in the Neighbourhood of the Critical State.* **P. Duhem.** (Comptes Rendus, 134. pp. 1272-1274, June 2, 1902.)—The author extends his former considerations on compressible viscous fluids [see preceding Abstract] to the case in which the fluid is near the critical state. At every point of the fluid and at every instant the temperature T and density ρ are supposed to have approximately their critical values. It is shown that while the density differs by a finite amount from ρ_0, the equilibrium value under the "fictive" pressure and at temperature T, the density of an element may vary very slowly; in such a state the fluid is in quasi-equilibrium, and the component velocities are very small at every point and at every instant; such a state is not permanent, the density at each point varying very slowly till it attains the value ρ_0. It is possible also to observe the fluid in such a state that it has sensible motion; if the accelerations are very large the rate of variation of density is no longer very small. In this way we may take account of the effect produced by the motion of a stirrer in a fluid near its critical state. If the accelerations are small the density of any material element varies very slowly, and the problem is mathematically the same as that of a dissolved substance diffusing slowly through the solvent; hence the similarity of the striæ in a fluid near the critical point to the motions in a solution having great differences of concentration at different points. W. S.

1992. *Diffusion of Two Portions of a Homogeneous Fluid into each other.* **K. Stanzel.** (Akad. Wiss. Wien, Sitz-Ber. 110. 2a. pp. 1038–1052, 1901.

From the Physikalisch-chem. Institut. Universität, Wien.)—The chance that a molecule initially at the origin of co-ordinates has at time t its x-co-ordinate between x and $x + dx$ is found to be $(A/\pi t)^{\frac{1}{2}} exp(-x^2 A/t)$, where A is a magnitude depending on the constitution of the substance, being of the form Kns^2/c for a simple cohesionless gas, but of much more complicated form in other cases. Here K is constant for all gases and the other letters bear their usual signification. The number of molecules which pass in time t from one half of a cylindrical vessel of length L into the other is then found to be—

$$n(A/\pi t)^{\frac{1}{2}} \int_0^{\frac{1}{2}L} du \sum_{i=-\infty}^{i=+\infty} \int_{u+2iL}^{u+(2i+1)L} dx \, exp(-x^2 A/t).$$

Comparison of von Obermayer's experimental results for the inter-diffusion of NO_2 and CO_2 (which have the same molecular weight) and of other gases with the results of the above calculation shows slight discrepancies, which may be explained by taking into account the cohesive forces which actually come into play or by assuming the dependence of s upon temperature. R. E. B.

1993. *On Some Problems of Elastic Equilibrium.* **O. Tedone.** (Accad. Lincei, Atti, 10. pp. 294–296, Dec. 15, 1901.)—This is a continuation of an earlier memoir [see Abstract No. 433 (1902)]. Using the notation of the preceding memoir he now gives, as a generalisation following immediately from the results there obtained, a solution of the problem of the determination of the elastic deformation of an isotropic homogeneous medium bounded by the faces of a rectangular triedron, when the displacements are given at every point on the surface. He points out that the method is also applicable to the case of a medium bounded by two planes at an angle commensurable with π —or by three planes forming a birectangular triedron, the third angle, which is not a right angle, being commensurable with π. The method also leads to a solution for the case where, instead of the superficial displacements, the superficial tensions are given. S. H. B.

1994. *Recording Beginning and End of Light Precipitation.* **O. L. Fassig.** (U.S. Weather Bureau, Bull. 31., pp. 213–214 ; Discussion, p. 214, 1902.)—A sheet of paper, on which fine lines are drawn in copying ink, having been used to catch the few drops of very small showers, it occurred to the author to place such sheets on a revolving drum so as to obtain time records in a simple, inexpensive way. **Oberholzer** remarked that he tried other devices for the same purpose, making the drops, *e.g.*, close an electric circuit ; he also referred to improvements of the tilting buckets, which were clogged by the dust and smoke, and did not tip fast enough in very heavy showers. H. B.

1995. *Air Movement and Atmospheric Pressure.* **J. W. Sandström.** (Öfvers. Kongl. Vet. Akad. Stockholm, Förh. 59. 3. pp. 87–104, March, 1902.)—From his previous researches upon the relation between temperature and movement of the atmosphere under stationary conditions, the author deduces the following rules for the distribution of the atmospheric pressure : (1) If the skies move more rapidly than the wind at the surface of the earth, to an observer placed in the direction of their movement the vertical distances of the isobaric surfaces will be greater at the right than at the left ; (2) in the opposite case, these distances will be greater at the left than at the right ; (3) on the hypothesis (1), the same distances in cyclones will be smaller in the

centre than at the edges, and *vice versâ* for anti-cyclones; the opposite taking place on hypothesis (2). These results having been given an analytical form, the author goes on to verify them by the outcome of the Berlin scientific aerostatical excursions. They are next applied to determine the reciprocal inclination of isobaric surfaces and the distribution of temperature in the neighbourhood of a meteorological station. The influence of moisture on the thus calculated quantities is finally pointed out. A. G.

1996. *Chinook Winds.* **E. J. Glass.** (U.S. Weather Bureau, Bull. 31. pp. 41–42; Discussion, p. 43, 1902.)—The westerly warm Chinook winds of the eastern slope of the Rocky Mountains are welcome, as they drive the snow from the peaks into the ravines, where it cakes, preventing destructive thaws. At Helena, Montana, which is situated in a gulch, temperatures of — 30° F. have been observed, whilst the thermometer was above zero at Unionville, 6 miles to the north, a few hundred feet higher up at the head of the gulch. The winds are accompanied by extraordinarily rapid rises of 40 and 50°; during the first hour of a Chinook, rises and falls of 20° may alternate within five minutes. Two photographs are given, showing ragged cumulus clouds travelling eastward at great speed over an exceptionally clear sky. According to **Clayton**, the Chinooks are not unknown in other parts of the United States. H. B.

1997. *Recording the Motions of the Atmosphere.* **F. H. Bigelow.** (Monthly Weather Rev. 30. pp. 80–87, Feb., 1902.)—The author advocates uniform methods, recommending the metric system, the universal use of certain symbols, and right-hand counter-clockwise rotation giving the azimuth of the point towards which the wind is blowing, this azimuth to be reckoned from south through east to north. In his rectangular or cylindrical co-ordinates, $+x$ refers to southward and radially outward motion; $+y$ to eastward and tangential counter-clockwise motion; $+z$ to zenithward and upward motion. He then explains his method of computing the resultant direction and velocity of air motion from observations extending over large areas. H. B.

1998. *Relation between General and Local Forecasts.* **F. J. Walz.** (U.S. Weather Bureau, Bull. 31. pp. 117–125; Discussion, pp. 125–127, 1902.)—The author discusses the difficulties of the general and local forecasts of the U.S. Weather Bureau with especial reference to the verification of forecasts as practised at the Central Office and at Chicago, where the author is stationed. The verification slips of H. J. Cox, in use at Chicago, distinguish between positive failures—weathers predicted which did not come—and negative failures—features which were not predicted.—**E. H. Bowie** recommended the author's suggestions; forecasts of probable minimum temperature are often asked for by dealers in perishable goods. H. B.

1999. *Warm Air Currents at High Altitudes.* **R. Assmann.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 24. pp. 495–504, May 1, 1902.)—When a balloon floats in the atmosphere, the ventilation of the aspiration thermometer fails, and solar radiation prevails; this accounts for the rises of up to 30°, registered in the higher atmosphere by the instruments of some of Hermite and Besançon's unmanned balloons. In order to prevent this floating and mere drifting, Assmann proposed to try small perfectly closed balloons, made of rubber, which will rise under continued expansion until they burst; the

subsequent fall is checked by a parachute. The author discusses the records obtained with such balloons on six occasions in 1901, when heights of 13 km. and even, on July 30, of 17 km. were reached with balloons from 1 to 2 m. in diameter. On July 30, Berson and Süring also ascended to 11,000 m., but they were unconscious at the extreme elevation. Five or six atmospheric strata of different temperatures were observed; the temperature gradient per 100 m. ranged from $-1{\cdot}46°$ through 0° to $+0{\cdot}24°$; in the stratum between 12·5 and 16 km. the temperature rose, on July 30, from -54 to $-49°$, then to fall again slowly. There was always a temperature inversion at altitudes between 10 and 15 km. These observations agree with those of Teisserenc de Bort [see Abstracts Nos. 644 and 1667 (1902)], who sends up paper balloons, however, of about 50 c.m. capacity. H. B.

2000. *Sky Polarisation and Weather Conditions.* **L. G. Schultz.** (U.S. Weather Bureau, Bull. 31. pp. 28–31; Discussion, p. 31, 1902.)—Having drawn attention to Dorsey's *résumé* on the blue colour of the sky [see Abstract No. 367 (1901)], the author briefly describes experiments conducted during the last three years at Walla Walla, Spokane, Kalispell, and Fort Worth on the polarisation of the sky with apparatus of the type formerly used by Pickering. Each of these stations has its own characteristic polarisation curves. Noon observations are difficult on account of cloudiness and topographical features. The polarisation is generally greater and more regular in the morning than in the evening; irregularities in the polarisation at sunrise are more frequently followed by atmospheric disturbances than those at sunset. High polarisation indicates settled weather; low polarisation cloudiness, the clouds appearing in that portion of the sky where the polarisation was weakest. The polarisation is a valuable indicator of otherwise invisible changes in clouds; when clouds are dissolving, the polarisation increases. The polarisation is weak in showery weather, strong in fair weather, though the sky may be covered with heavy cumulus clouds.—**Abbe** and **Moore** dwelt on the importance of these studies since the connection between polarisation and weather has often been denied. H. B.

2001. *May Temperature Curve for Baltimore.* **O. L. Fassig.** (U.S. Weather Bureau, Bull. 31. pp. 68–69, 1902.)—While there is some basis for the popular belief in a cold wave for the days May 11–13 in Central Europe, the author finds that the temperature curves of Baltimore for the thirty years 1871–1900 show a well-defined rise for the days May 9–12. The thermometer rises during that period about 4° above the average of the days May 8–13. H. B.

2002. *Eclipse Meteorology.* **F. H. Bigelow.** (U.S. Weather Bureau, Bull. 1. pp. 13–166, 1902.)—This volume contains the reports of observers at American stations during the total solar eclipse of May 29, 1900. Summary tables are provided to show the mean variations of pressure, temperature, vapour pressure, wind velocity, cloudiness, &c. In the instrumental section the author concludes that a short focus lens with secondary magnifier is preferable to the long focus objective used to give direct image. Interesting details are given of appliances for erection of instruments not provided with observatory refinements. The effects of the passage of the moon's shadow on the various meteorological elements were observed at sixty-two stations, which were so distributed along the path of totality that the eclipse effect could be differentiated from the ordinary diurnal changes. Generally speaking there appears to have been a lowering of temperature of about

4° or 5° F., a lowering of the vapour pressure by 0·007 in., and a decrease in wind velocity of about 1 mile an hour.

Considerable discussion is given of the form presented by the photographs of the corona obtained in relation to the predicted features based on the electromagnetic theory of the solar surroundings which is put forward by the author. C. P. B.

2003. *Altitude Observations at Sea.* **J. Joly.** (Roy. Dublin Soc., Proc. 9. pp. 559–567, May, 1902.)—The paper describes a simple method of observing the altitude of a celestial object at sea at night-time or when the horizon is obscured. A Board of Trade rescue signal has attached to it 3 or 4 fathoms of marlin and a sinker. The bearing of some recognisable star having been taken, the signal is dropped overboard and the course of the ship altered so that the star and signal are both astern. The ship is run a mile, as measured by the log, and an observation is made of the elevation of the star over the signal. The altitude can then be corrected from tables. A table is given for correction for the dip of the signal due to waves of different heights, and another method of carrying out the observation by means of two stars is explained. G. E. A.

2004. *Repulsive Force of the Sun.* **H. Deslandres.** (Comptes Rendus, 134. pp. 1134–1136, May 20, 1902.)—The author points out that several of the suggestions propounded recently by Arrhenius, have been previously noted in various communications dealing with the results obtained from observations of the total eclipse of the sun at Senegal, West Africa, in 1893. The emission of kathode rays by the higher rarefied layers of the solar atmosphere has also been proposed by the present author and by Birkeland. The action of these on the earth's atmosphere is thus possibly concerned in the production of auroræ. C. P. B.

2005. *Computation of Spectroscopic Binary Orbit.* **H. N. Russell.** (Astrophys. Journ. 15. pp. 252–260, May, 1902.)—The author gives an extension of the method originated by Wilsing, in which the observed radial velocity of the system is developed into a trigonometrical series, and the elements are found by comparing this series with the corresponding analytical expression for the velocity. As developed by Wilsing, the method was only applicable to orbits of very small eccentricity.

The method at present in general use (that of Lehmann-Filhe, Astronomische Nachrichten, Band 136, 1894) is somewhat more expeditious in practice, but as in the new method described the orbit is determined from twelve points on the velocity curve instead of four, the result should be more accurate. C. P. B.

2006. *Kinetic Theory of Planetary Atmospheres.* **G. H. Bryan.** (Nature, 66. p. 54, May 15, 1902.)—This note is in criticism of an article by Rogovsky [see Abstract No. 446 (1902)], describing the possible escape of various gaseous molecules from the outer limits of the earth's atmosphere. Taking the statement that a gas would escape if the velocity required by a molecule to overcome the planet's attraction and fly off to infinity is not more than 10·22 times the most probable velocity, Bryan calculates that it is so rare for a molecule to attain such a speed that a period of $5{\cdot}371 \times 10^{10}$ years would elapse before a single cubic centimetre of gas (helium) could escape from the earth. From this he concludes that if helium is actually escaping some other factor must be in operation. C. P. B.

REFERENCES.

2007. *Some Peculiarities of Springs and a Spring Testing Machine.* A discussion by **S. W. Baldwin, A. A. Cary,** and **A. Kingsbury.** (Amer. Soc. Mech. Engin., Trans. 23. No. 924, pp. 277–297, 1902.)

2008. *Experiments on Helical Springs.* **C. H. Benjamin** and **R. A. French.** (Amer. Soc. Mech. Engin., Trans. 23. No. 925, pp. 298–302 ; Discussion, pp. 302–312, 1902.)

2009. *The Equilibrium of an Elastic Circular Cylinder.* **F. Hasenöhrl.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 1026–1037, 1901.)—Jaerisch has integrated the differential equations of elastic equilibrium of a circular cylinder under prescribed surface conditions, starting from cylindrical co-ordinates. The author solves the problem for the infinitely long circular cylinder, with given surface-displacements or given surface-tractions, setting out from the Cartesian equations. W. S.

2010. *Archimedes' Principle in Gases.* **E. C. Sevérin.** (Annal. Sci. de l'Univ. de Jassy, 2. pp. 45–51, April, 1902.)—Experimental and demonstrational apparatus for the determination of the density of gases are described. A. D.

2011. *Artificial Horizon.* **F. Verde.** (Rivista Sci.-Industriale, 34. pp. 49–55, April 15, 1902.)—An application of photographic methods of observation to a gyroscopic apparatus. A. D.

2012. *The Constitution of Matter and Ether.* **J. Fraser.** (Roy. Soc. Edinburgh, Proc. 24. pp. 26–64, March, 1902.) G. W. DE T.

2013. *Divisibility of the Atom.* **A. S. Mackenzie.** (Frank. Inst., Journ. 153. pp. 451–468, June, 1902.)—This is mainly a historical sketch of recent investigations. G. W. DE T.

2014. *Fundamental Principles of Mechanics.* **H. A. Lorentz.** (Konink. Akad. Wetensch. Amsterdam, Versl. 10. pp. 876–896, April 19, 1902.)—This is an attempt to base mechanical science on one fundamental principle, as Hertz did in his "Prinzipien der Mechanik," without, however, assuming any hidden movements *within* masses invisible to us, as Hertz did. In order to be able to dispense with those ideas the author introduces the idea of force in the sense current in mechanics. A. G.

2015. *Bipolar Fields of Force of Diffusion.* **S. Leduc.** (Comptes Rendus, 134. pp. 1204–1205, May 26, 1902.)—Referring to his previous paper [see Abstract No. 1279 (1902)], the author gives a further account of his method of representation of fields of force by means of photographs showing the phenomena of diffusion, and proceeds to describe his representation of a bipolar field and his photographs of the spectra of these fields of force in liquids. J. J. S.

2016. *New Collimating-Telescope Gun-Sight for Large and Small Ordnance.* **H. Grubb.** (Roy. Dublin Soc., Trans. 7. pp. 321–329, 1901.)

2017. *New Geodetical Instruments.* **H. Grubb.** (Roy. Dublin Soc., Trans. 7. pp. 385–390, May, 1902.)—The principles of the author's gun-sighting apparatus are utilised in the construction of the plane table, level, prismatic compass, and clinometer. The instruments are suitable for rapid surveying where great accuracy is not required, such as road- and railway-making and property conveyancing. The probable error is less than two minutes of arc. Descriptions of the above instruments are given, with sections and several photographs of the instruments in use. G. E. A

2018. *The Height Diagram.* **E. Hammer.** (Zeitschr. Instrumentenk. 22. pp. 81–88, March, 1902.)—The use of diagrams as an aid to the measurement of heights in surveying is discussed, and illustrated by diagrams and tables.
G. E. A.

2019. *Geodesic Operations at the Equator.* **H. Poincaré.** (Comptes Rendus, 134. pp. 965–972, April 28, 1902.)—This is a summary of the Report made by **Bourgeois,** the chief of the expedition, to the Committee of the French Academy of Science. G. G.

2020. *Meteorological Observations made at the Perth Observatory and other Places in Western Australia, under the direction of W. E. Cooke.* (Meteorological Report, Perth Observatory, pp. 5–121, 1901.)

2021. *Circulation of the Atmosphere in High and Low Areas.* **F. H. Bigelow.** (Monthly Weather Rev. 30. pp. 117–125, March, 1902.)—General description of the vectors obtained by observation for elevations of 0, 1,000, 3,000, 5,000, 7,500, 10,000 m., and determination of the vector values. [See also Abstract No. 1997 (1902).] H. B.

2022. *Flood Forecasting for Rivers of Small Drainage Area.* **C. F. v. Herrmann.** (U.S. Weather Bureau, Bull. 31. pp. 158–167, 1902.)—The author discusses the difficulties of flood forecasting with special regard to North Carolina under the four headings of geological, topographical, and meteorological conditions, and of precipitations. H. B.

2023. *Fog Studies.* **A. G. McAdie.** (U.S. Weather Bureau, Bull. 31. pp. 31–34; Discussion, pp. 34–35, 1902.)—The paper concerns the fogs near San Francisco [see Abstracts No. 2389 (1900), and Nos. 602, 1250, and 1864 (1901).] Six beautiful photographs of fog clouds, comprising a remarkable fog pyramid, are reproduced.—The discussion by **Bigelow, Clayton, Odenbach,** and **Moore** deals with the production of ocean fogs by the intermixing of air currents. H. B.

2024. *Hurricanes, especially of Porto Rico and St. Kitts.* **W. H. Alexander.** (U.S. Weather Bureau, Bull. 32. pp. 7–79, 1902.)—The subject is discussed under the headings: Theories of the origin of rotary storms; premonitory signs; approach and passage of West Indian hurricanes; barometers; U.S. Weather Bureau in the West Indies; historical notes on the hurricanes, earthquakes, &c., of Porto Rico and St. Kitts since 1515. [Compare Garriott, Abstract No. 604 (1901).] H. B.

2025. *Explanation of Celestial Phenomena by Hertzian Waves.* **C. Nordmann.** (Comptes Rendus, 134. pp. 530–533, March 3, 1902.)—The author summarises the reasoning suggested for explaining the various solar and cometary phenomena as the result of Hertzian waves originating in the solar surface. C. P. B.

2026. *Theory of a Cosmic Cycle.* **F. W. Very.** (Amer. Journ. Sci. 13. pp. 47–58, Jan.; 97–114, Feb.; and pp. 185–196, March, 1902.)—These three articles are already too condensed for detailed abstraction. The whole range of stellar evolution is discussed from the standpoint of modern thermodynamics and spectroscopy.
C. P. B.

2027. *Spectra of the Aurora Borealis and of the Sun.* **H. Stassano.** (Annal. Chim. Phys. 26. pp. 40–57, May, 1902.)—The author has collected together measurements of as many lines as possible which have been observed by various physicists and compared them with Liveing and Dewar's measurements of the spectrum of the most volatile gases of the atmosphere. He has also done the same for the chromospheric and prominence spectra of the sun. He comes to the conclusion that the aurora consists of helium, hydrogen, neon, and argon. Many of Liveing's and Dewar's lines he selects are yet unassigned. E. C. C. B.

LIGHT.

2028. *Molecular Gratings and Dispersion* (I). **E. Carvallo.** (Soc. Franç Phys., Séances, 3. pp. 198–202, 1901.)—At the Congrès international des méthodes d'essais des materiaux de construction, in 1900, a paper was read by M. Ricour on the molecular constitution of bodies, in which reference is made to a theory of dispersion of colours advanced by Sénarmont in 1860. Sénarmont assumes the ether to have a periodic constitution, like a molecular grating, instead of being uniform. By means of an equation in finite differences, he derives a dispersion formula much like Baden-Powell's, containing only two constants. Ricour applied this formula with some success to Mascart's observations of quartz in the region $768\,\mu\mu - 336\,\mu\mu$. Carvallo however, finds that on a more extended test, from $2171\,\mu\mu - 202\,\mu\mu$, it breaks down completely. He remarks further that it is impossible to explain the laws of double refraction by Sénarmont's method, or by any modification of it. A. E.

2029. *Alteration of Optical Properties of Glass by Elastic Deformation.* **F. Pockels.** (Ann. d. Physik, 7. 4. pp. 745–771, April 8, 1902.)—Experiments were carried out on several Jena glasses whose elastic and thermal properties were accurately known. The calculations were based on Neumann's equations for the influence of elastic deformation on the transmission of light in amorphous substances. The author arrives at the following conclusions: (1) Double refraction due to a state of thrust is, as has usually been assumed, negative for most glasses, but is positive for flint glasses containing a large percentage of lead. Hence it should be possible to make a flint glass containing lead in such proportion that there would be no double refraction for light of a certain wave-length. The result of an experimental melting tended to confirm this view. Dispersion due to mechanical thrust is generally so small as to be barely measurable. It is only considerable in the heaviest flint glasses. (2) Change of index, absolute or relative, due to hydrostatic compression increases with the density and index. The amount of change does not agree with any formulæ which have been put forward as connecting index with density. Newton's law $(n^2 - 1)/\rho = \text{const.}$, gives the best agreement, and Lorentz's the worst. (3) By the pure temperature coefficient of the index is meant the result obtained by subtracting the portion of the coefficient due to mere change of density. This quantity was calculated for four glasses, the value obtained being always positive, and increasing rapidly with the percentage of lead. (4) Dispersion may either increase or decrease as the pure temperature coefficient increases. A. E.

2030. *Chemical Action of Light.* **G. Ciamician** and **P. Silber.** (Accad. Lincei, Atti, 11. pp. 277–284, April 6, 1902.)—A solution of 60 grams of nitrobenzene in 200 c.c. of absolute alcohol was exposed to the action of light during the whole summer, after which 50 grams of unaltered nitrobenzene was recovered, the remaining compounds yielding 6·6 grams of a mixture of hydrochlorides from which were separated: quinaldine, aniline, a tertiary base and an aldehydic substance. *m*-Nitrotoluene gives the corresponding methyl-quinaldine and *m*-toluidine, the other nitrotoluenes yielding similar products. *o*-Nitropiperonaldehyde in benzene gives *o*-nitrosopiperonylic acid

whilst *o*-nitrocinnamaldehyde remains unchanged. *o*-Nitrobenzaldehyde in alcoholic solution yields mainly the two compounds, $NO_2 . C_6H_4 . CO_2C_2H_5$ and $ON_2(C_6H_4 . CO_2C_2H_5)_2$. T. H. P.

2031. *Testing Astronomical Objectives.* **H. Lehmann.** (Zeitschr. Instrumentenk. 22. pp. 103–109, April, 1902.)—In Hartmann's method [see Abstract No. 1013 (1900)], each zone of the objective is examined separately by covering the remaining surface and taking photographs within and without the focus, for micrometric measurement. The source must be monochromatic, and the following remarks therefore only apply to monochromatic observation. The author has used the method to test a great number of objectives, and finds that it enables the fundamental errors to be determined with a degree of accuracy far surpassing that attainable by any of the usual tests. The lens-polisher is therefore enabled to carry correction to a higher stage of refinement. The method is especially useful for the detection of small mechanical irregularities. Curves and tables are given illustrating the performance of lenses at different stages of correction. It is possible to make objectives giving very nearly point-images by monochromatic light, and in view of the high resolving power thus obtainable, the author suggests that double-stars and fine planetary details might be observed monochromatically by employing various light filters. The objective need then only be corrected for spherical aberration. A. E.

2032. *Lenses for Keratocone.* **J. Janssen.** (Comptes Rendus, 134. pp. 1121–1123, May 20, 1902.)—In this affection the front of the cornea assumes a projecting parabolic form which induces an extreme myopia. To compensate this lenses may be used whose inner surface corresponds to the abnormal and the external to the normal form of the cornea: but in practice a spherical form given to the inner surface works better for objects off the optic axis. If necessary, another ordinary lens may be added for any ordinary shortsightedness which may be present. A. D.

2033. *Photo-Micrographic Device.* **F. E. Ives.** (Frank. Inst., Journ. 153. pp. 371–378, May, 1902.)—Assuming that the eye can focus parallel rays, either unaided or with the aid of a supplementary lens, the object is brought into focus in the microscope in the ordinary way. Then on a baseboard there is a support for a camera attachment, into which the microscope is put in position after having been adjusted; this camera attachment has the same rotation as the body of the microscope, and can therefore be brought to fit the microscope without altering the slope of the latter. The camera has a 10-in. lens and 10-in. box: this brings the parallel rays from the microscope to focus on the plate with the same amplification as the eye saw in the microscope. Monochromatic light is best, and isochromatic plates. This arrangement can be relied upon to reproduce clearly whatever detail the eye saw in the microscope. A. D.

2034. *Stopping down Lens of Human Eye.* **W. Andrews.** (Nature, 66. p. 31, May 8, 1902.)—The author, who uses convex spectacles, can read the smallest print at 4 in. through an aperture one-fiftieth of an inch in diameter in a metallic disc. This corresponds to stopping down the lens to about *f*/25. A. D.

2035. *Urine as a Photographic Developer.* **R. A. Reiss.** (Comptes Rendus, 134. pp. 1207–1208, May 26, 1902.)—The latent image of an

exposed plate is not developed when treated with fresh urine, but if the latter be rendered alkaline by the addition of a solution of potassium carbonate, that image appears rapidly without, however, sufficient density being obtained to enable a satisfactory point to be made. The prolonged action of the urine developer fails to secure an increased density. The negative can, however, be intensified by the ordinary mercury or uranium methods, and fixation can be effected by the use of the hyposulphite of soda bath. The colour of the reduced silver is yellowish. On the addition of potassium carbonate to the urine, ammonia is liberated as a result of the partial decomposition of the urea contained in the urine which takes place. Urine which has become alkaline by exposure to the air developes the latent image without the addition of potassium carbonate.

Ordinary developers such as hydroquinone, pyrogallol, &c., when diluted with urine instead of water were found to be much more energetic in their action, without the tendency to fog being sensibly increased. The active agent in urine was found to be urea, a solution of the chemically pure substance and potassium carbonate developing the latent image. C. E. A.

2036. *Quartz Prisms.* **R. Straubel.** (Ann. d. Physik, 7. 4. pp. 905–908, April 8, 1902.)—Cornu and v. Lang have shown how the peculiar doubly refracting property of quartz in the direction of the optic axis may be made manifest by means of a single prism, having the plane bisecting its vertical angle perpendicular to the optic axis, and which is set for minimum deviation. Suppose now that instead of the whole prism we take one of the half-prisms obtained by cutting through the plane of bisection, and, adopting an auto-collimation arrangement, allow the light to be internally reflected at the cut surface. At first sight this arrangement would appear to be equivalent to the foregoing. The author, however, found no trace of doubling of spectrum lines. The following is the explanation : A wave refracted into the prism in the direction of the optic axis is separated into two which are circularly polarised in opposite senses, and have different velocities and therefore different indices of refraction. The deviation again depends on the index. Hence, with Cornu's prism, a single incident-wave gives rise to two emergent-waves deviated in different direction. But reflection changes a right-handed rotation into a left-handed, and *vice versâ*. Hence in the half prism, the component which is least deviated on entering and travels fastest before reflection, will travel slowest after reflection and be most deviated at emergence. The total deviation is therefore the same for both waves. The fact that the auto-collimation method gives single lines with a quartz prism with its second face cut perpendicular to the axis, may have some importance for spectrographic investigations in the ultra-violet. The method possesses one advantage over Fraunhofer's in requiring only one objective of fluorspar instead of two. If the unreflected light emerging from the second face of the prism is observed through a telescope the lines still appear double ; and the increased separation towards the blue end of the spectrum, owing to the dependence of rotation upon wave-length, is very marked. By revolving the prism the observer can convince himself that the two images never quite coincide, showing that the two sections of the wave-surface by a cross-section of the prism have no common point. The same phenomena are seen on reversing the arrangement so that the light is incident normally at the face perpendicular to the axis. A telescope of power 6–8 was sufficient to show the effect, and with a power of 15 diameters all the lines were doubled. The half-prism had an angle of 30°. A. E.

2037. *Mascart's Ether Experiment.* **R. Wachsmuth** and **O. Schönrock.** (Deutsch. Phys. Gesell., Verh. 4. 8. pp. 183–188, April 25, 1902.)—As a contribution towards a repetition of the above experiment to find whether the earth's motion affects the rotation of the plane of polarisation of an E-W ray passing through quartz, the authors criticise Mascart's arrangement and especially his use of very thick quartz plates. By the use of quartz plates of thicknesses 109·6, 24·1, and 7·4 mm. it is shown that the percentage error in measuring the angle of rotation is pratically constant. Hence they conclude that pure quartz plates about 1–3 cm. thick are better than very thick plates, and that if the difference to be observed should be more than 1/100000 of the angle of rotation, this could be demonstrated by means of a half-shadow polarimetre. G. E. A.

2038 *Differential Equations of Fresnel's Polarisation Vector.* **J. Walker.** (Roy. Soc., Proc. 70. pp. 37–43, May 12, 1902.)—In this paper, the equations for crystalline media are derived in a manner analogous to that used by Voigt in the case of isotropic media, in place of deducing them, as done by Voigt, from the isotropic equations by means of the principle of least action. Extensions are suggested of Fresnel's theorem respecting the ellipsoid of polarisation to active crystals, including those magnetically active.
G. W. DE T.

2039. *Magnetic Rotation-Polarisation of Absorbing Substances.* **H. du Bois.** (Ann. d. Physik, 7. 4. pp. 944–945, April 8, 1902.)—In view of several papers recently published on this subject, the author calls attention to some remarks made by himself (Rapp. Congr. de Phys. 2. Paris, 1900) to the effect that the magnetic rotary polarisation for the compounds of the different metals of this series is of varying sign. He further states that he has not been able to observe any particular effect exerted by magnetism on the very characteristic absorption spectrum of a solution of strongly magnetic erbium chloride. T. H. P.

2040. *The Zeeman Phenomenon.* **A. Korn** and **K. Stoeckl.** (Ann. d. Physik, 8. 2. pp. 312-325, May, 1902.)—This is the first of a series of papers dealing with magneto-optics, dispersion, and aberration. The authors proceed from that form of the electromagnetic theory of light in which the light vector is taken proportional to the electric intensity vector, and they will show that the phenomena in question can be explained by the mechanical conceptions of electric phenomena which are the basis of the hydrodynamical theory. The ether is a fluid incompressible when rapid motions are concerned; a conductor is a continuous mass-system endowed with friction; a dielectric consists of the ether and embedded conducting particles, which, however, are in general so far apart that frictional forces do not come into play. To explain the Zeeman effect the authors employ the Faraday-Maxwell idea that a magnetic particle possesses a rotation, the moment being proportional to the angular velocity; on the hydrodynamical theory (see Korn, Sitzungsber. d. math.-phys. Kl. d. bayer. Akad. d. Wissensch. 28. p. 129, 1898) a particle rotating with very great velocity is a magnet whose axis is that of rotation and moment proportional to the angular velocity. The ordinary Zeeman doubet is explained either on the Faraday-Maxwell rotation hypothesis or on the hydrodynamical theory of magnetic particles; the triplet cannot be explained on the basis of purely transversal waves, but necessitates consideration of the longitudinal component; the Cornu quadruplet and the inverse

triplet of Becquerel and Deslandres, which have not hitherto been deduced (without assuming complex ions) from the electromagnetic theory of light, are explained on the basis of the hydrodynamical theory. W. S.

2041. *The Optical Rotation of Sugar Dissolved in Amines.* **G. M. Wilcox.** (Journ. Phys. Chem. 6. pp. 339-342, May, 1902.)—The author has already shown that sugar has a higher rotation in pyridine than in water [see Abstract No. 30 (1902)]. He now finds that allylamine, amylamine, isopropylamine, and ammonia act in the same way as pyridine. On the other hand, the hydroxides and salts of the alkali metals when added to aqueous sugar solutions cause the rotatory power to decrease. D. H. J.

2042. *The Constitution of Matter and Spectroscopy.* **B. Eginitis.** (Comptes Rendus, 134. pp. 1137–1139, May 20, 1902.)—From his own experiments and those of Schuster and Hemsalech [see Abstract No. 1066 (1900)] on the spark spectrum, the author draws the following conclusions : The intensity of the different rays of a metal depends on the nature of the metals present along with it and on the nature of the medium. Some rays of the simple metals form groups whose variations are due probably to difference in constitution of the radiating particles and in the nature of the poles. A relation seems to exist between those groups and the groups of rays which issue from the poles with equal velocities. During the discharge metallic vapours exhibit properties varying with their nature, and differing considerably from those of air. The constitution of matter may be examined by using varying inductance in the circuit. W. S.

2043. *Polar Light Observations at Göttingen.* **E. Wiechert.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 2. pp. 182-184, 1902.)—Observations conducted at the new geophysical observatory near Göttingen with a powerful spectroscope, made by Brunnée, since November, 1901, demonstrate that the polar light line is very frequently—but not always—discernible in the north and east, further at some elevations in the south and occasionally all over the sky. To the naked eye nothing beyond a faint luminiscence was ever visible. H. B.

2044. *Actino-electric Phenomena.* **A. Nodon.** (Comptes Rendus, 134. pp. 1491–1493, June 23, 1902.)—When luminous, or ultra-violet, radiations fall upon one face of a thin conducting plate, the other face emits radiations similar to Röntgen or radium rays. This is shown by suspending a brass sphere within a blackened zinc case, and projecting upon the latter a pencil of rays from the voltaic arc, or magnesium, or the sun. The sphere is insulated and forms with the zinc case a condenser which is connected to a single gold-leaf electrometer. The sphere being charged, the incidence of the light produces discharge as shown by the electrometer, although the sphere is completely shielded from any direct incidence of the light. The discharge is rapid in proportion to the intensity of the light and to the presence of radiations of small wave-lengths. These radiations, induced on the dark side of a thin metal plate or the bright side of a thick metal plate, can traverse easily thin sheets of metal, and also wood, glass, &c. They differ from kathode rays, and appear to possess properties intermediate between those of Röntgen and radium rays. The author terms them radio-actinic rays. J. W. P.

2045. *Röntgen Rays.* **J. Wimshurst.** (Röntgen Ray, Archives, 6. pp. 102–104, May, 1902.)—Röntgen rays originate upon the anode immediately over the end of the positive terminal wire, and the point of light from which these rays originate is hemispherical in form; from this the rays move outwards radially in every direction, a slightly greater efficiency being imparted to those rays which move outwards in lines which are at a small angle to the plane of the anode. The tube when excited emits invisible (Röntgen) rays of great penetration, and also visible light which is slightly penetrative either when used direct or when reflected. Both the Röntgen rays and the visible light enter into and fill the whole space of the apartment in which the tube is excited. When the Röntgen rays are passing out from the tube they will even without any reflector enter and pass through a tube which is placed at a right angle or at any angle to their normal course; the loss of efficiency is, however, considerable. The dense metals are more efficient than the lighter metals when used as reflectors. Possibly the great resistance may generate heat and, following this, light, and also Röntgen rays of rapid vibration immediately in front of the anode. A. D.

2046. *Phosphorescence in Röntgen-ray Bulb.* **J. H. Gardiner.** (Röntgen Ray, Archives, 6. pp. 104–106, May, 1902.)—The probability is very strong that the phosphorescence in an excited Röntgen-ray bulb, which is bounded by the anti-kathode zone, is due, not to the reflected kathode stream, but to easily absorbed Röntgen radiations, which give up their energy partly as phosphorescence, and also produce secondary Röntgen radiations at the illuminated surface. A. D.

2047. *Chemical Reactions Produced by Radium.* **Berthelot.** (Annal. Chim. Phys. 25. pp. 452–458, April, 1902.)—The author, after an account of researches already described [see Abstracts Nos. 298 and 459 (1902)], suggests that the observations should lead to a series of methodical experiments designed to compare together the actions of light, those of the electric effluvium, and those of radium, in determining chemical transformations, and as serving as sources for the energy consumed in these transformations. J. J. S.

2048. *Induced Radio-activity.* **A. Sella.** (Accad. Lincei, Atti, 11. pp. 369–373, May 4, 1902.)—In the Rendiconti of the Accad. Lincei, xi. p. 242 (Abstract No. 1520 (1902)], the author showed that on long leaving within a closed space the air exposed to emanations from thoria and producing an electric effluvium in this air between a point and a plane, that portion of the plane which was struck by the effluvium became radio-active with contours corresponding to those of Kundt's electric figures. Kundt's figures can be readily obtained by producing an effluvium in air rendered smoky by a smoky flame or by the dust from burning magnesium, the dust being at once deposited on the metal. With stale thoriated air the induced radio-activity is the same whether the points are positive or negative; and it is as if the thoria emanations had in time agglomerated into something resembling lampblack or magnesia dust. When this thoria dust has once settled down, a second effluvium between another point and plane in the same space will not produce any effect; the first effluvium has cleared the enclosed air of thoria dust. On filtering the stale thoriated air through wadding the dust is removed, but the wadding becomes powerfully radio-active; fresh thoriated air is not affected in this way. Stale ordinary air presents similar phenomena

in minor degree, but the radio-activity of the wadding used as an air-filter very rapidly falls off. On electrolysing the commercial liquid for impregnating incandescent mantles (a solution of 99 per cent. nitrate thoria, 1 per cent. of nitrate ceria) the negative electrode becomes powerfully radio-active, the radio-activity rapidly falling off afterwards; nitrate of uranium gives no result. A. D.

REFERENCES.

2049. *Total Reflectometer.* **C. Klein.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 8. pp. 104-119, Feb. 13, 1902.)—This is a continuation of an 1889 paper. In Part 3 total reflectometers suitable for investigating thin plates of crystal are discussed, and Part 4 treats of the system of crystallisation of pennin and of an unsuccessful attempt to explain its structure by means of crossed, biaxial lamellæ. G. E. A.

2050. *Stokes' Theory of Aberration in Ether of Variable Density.* **H. A. Lorentz.** (Archives Néerlandaises, 7. pp. 81–87, 1902.)—This is a French translation of the author's paper in Akad. Wetensch. Amsterdam Verslagen, 7. p. 523, 1899. G. W. DE T.

2051. *Application of Diffraction to Astronomical Measurements.* **C. Hillebrand.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 989–1025, 1901.)—The only reliable method for measuring the apparent diameter of a source of light such as a fixed star is that in which diffraction phenomena are produced by two slits or mirrors placed in front of the objective of the telescope. It was first used with success by Michelson (see Phil. Mag., 1890). The author gives a complete analysis and critical discussion of the method for slits and mirrors when the source is circular or elliptic, or when there are two circular sources. W. S.

2052. *Photographic Permanence.* **C. F. Himes.** (Frank. Inst., Journ. 153. pp. 359–370, May, 1902.)—The principal point made in this lecture is that a first-class albumen print may be regarded as the standard of permanence, not on *à priori* grounds, but as an experimental fact. C. E. A.

2053. *Photography of Disturbances in Air.* **H. S. Allen.** (Nature, 65. pp. 575–576, April 17, 1902. From Proc. Roy. Philosoph. Soc. Glasgow, Dec. 4, 1901.)—Methods are described, based on Toepler's method of striæ. Electric discharges produce initial variations of density comparable to explosions rather than to sound-waves; but the subsequent oscillations produce very little compression. Experiments on flames, jets, and vortex-rings are described. A. D.

2054. *Photographic Appliances.* **O. Hertwig.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 22. pp. 450–454, April 24, 1902.)—Apparatus described, made by Zeiss, with mirror and inversion prism, for photographing such objects as frog's eggs in course of development, from above and from below, in rapid succession. A. D.

2055. *Photographic Papers.* **A. I. Cohn.** (Soc. Chem. Ind., Journ. 21. pp. 582–587, May 15, 1902.)—The paper deals very fully with the manufacture and practical employment of blue-print and black-print photographic papers. G. W. DE T.

2056. *Radio-activity and the Constitution of Matter.* **R. P. Lucàs.** (Soc. Belge Élect., Bull. 19. pp. 289–305; Discussion, pp. 305–309, May, 1902.)—The paper gives an excellent sketch of the present state of knowledge of radio-activity. G. W. DE T.

2057. *Actinism of Röntgen Rays.* **J. O. Heinze, Jr.** (Amer. Journ. Sci. 13. pp. 313–314, April, 1902.)—Experiments to show that photographic effect may fall off where fluorescent effect increases. A. D.

HEAT.

2058. *Thermal Expansion of Porcelain.* **A. E. Tutton.** (Phil. Mag. 3. pp. 631–642, June, 1902. Paper read before the Physical Society, March 14, 1902.)—Bayeux and Berlin porcelains are employed for the reservoirs of air thermometers. Hence an exact knowledge of the expansion is practically valuable. The Bayeux variety is here investigated by the interference dilatometer. Advantages here attained over the Fizeau method are: (1) The employment of a micrometer method of measuring the position and width of the interference bands; (2) use of auto-collimation; (3) use of C hydrogen light in place of sodium light; (4) special arrangement which permits extension of the range up to 120°. An aluminium compensator is used for reflecting the hydrogen light, as the porcelain is incapable of polish. The specimens used were tubes about 12 mm. long, 17 mm. diameter, and 3 mm. wall thickness. Tables of readings are given for three specimens; the mean value of the linear coefficient $(a + bt)$ between 0° and 120° is $10^{-9}(2522 + 7{\cdot}43t)$. Comparison with the results of Bedford and Chappuis, and criticism by Callendar, is given. J. W. P.

2059. *Variable and Absolute Specific Heats of Water.* **J. Macfarlane Gray.** (Inst. Civil Engin., Proc. 147. pp. 3–32, 1901–1902.)—Assuming that water would have a constant specific heat if bereft of volume, the author, by a process which is not clear and can only be approximate, finds—as previously in 1889—an expression of the form $\theta d(vdp/d\theta)/d\theta$ for its extra specific heat when it occupies volume v at the absolute temperature θ. The circumstances of the differentiations are not specified nor clearly determined, but in the calculations made the values of $dp/d\theta$ are taken for the saturated states. So interpreted, this formula appears to agree very satisfactorily with the results of Callendar and Barnes's experiments, which range from 4° to 60° C., and also with the results deducible from Regnault's experiments at higher temperatures when proper allowance is made for the variation of the specific heat of the cold water in his calorimeter. [See also Abstract No. 1879 (1899).] R. E. B.

2060. *Specific Heats and Heats of Evaporation of the Paraffin and Methylene Hydrocarbons.* **C. F. Mabery** and **A. H. Goldstein.** (Amer. Acad., Proc. 37. pp. 539–549, March, 1902.)—With the paraffin hydrocarbons the author finds there is a uniform decrease in the specific heat as the molecular weight increases. It is found also that the product of specific heat and molecular weight divided by the number of atoms in the molecule gives an almost constant number, 2·23, for all the members of this series examined. For the methylene hydrocarbons, C_nH_{2n}, a similar relation holds, the constant having a slightly higher mean value. Various crude oils from different sources were also examined, and the author concludes that the specific heat must be regarded as an important property from a practical point of view. Results are also given of several measurements of the heat of vaporisation. The numbers obtained indicate a rapid falling off in latent heat as the molecular weight increases. T. H. P.

2061. *Vapour Composition.* **H. R. Carveth.** (Journ. Phys. Chem. 6 pp. 237–256, April, and pp. 321–338, May, 1902.)—Using an apparatus o the type of the Landsberger Boiling-Point Apparatus it is shown how th boiling-points of saturated solutions may be determined by bubbling vapou of the solvent derived from the saturated solution into the saturated solutio *plus* solid non-volatile solute contained in the inner tube. Reference is mad to the lowering effect produced by the presence of excess of solid solute o the apparent boiling-point of a saturated solution. In this method of vapour heating superheated vapour derived from a higher boiling solution may be employed. This procedure is stated to be the only one which gives accurat results. The boiling-point curve for a mixture of two volatile component may be similarly studied. In the case of three components the displacemen in vapour composition produced by the addition of the third component i discussed. It is pointed out that the work of fractionation will be hinderec if the third component added is more soluble in the more volatile com ponent, and helped if it is more soluble in the less volatile component Other more complicated cases are considered. F. G. D

2062. *Molecular Attraction.* **J. E. Mills.** (Journ. Phys. Chem. 6 pp. 209–236, April, 1902.)—From the application of the gas law to solu tions the author concludes that the total energy *per se* of a molecule mus be the same in the liquid as in the gaseous state at the same temperature, and that therefore, in general, the energy to change a liquid into gas is spent in overcoming the external pressure and in altering the distance apart of the molecules. Assuming that the attraction between the molecules varies inversely as the square of their distance apart, he deduces the formula $(L_T - E_{IT})/(L_t - E_{It}) = (\sqrt[3]{d_T} - \sqrt[3]{D_T})/(\sqrt[3]{d_t} - \sqrt[3]{D_t})$, where L_T, E_{IT}, d_T, D_T are, for temperature T, the latent heat, energy required to overcome external pressure, and densities corresponding to volumes v and V. This affords a means of testing the above assumption, and the results are in its favour, and also show that the absolute molecular attraction is only slightly affected by changes in temperatnre, and depends primarily upon the chemical constitution of the molecule and not upon its mass. Confirmation of these conclusions is obtained by means of Crompton's equation, $L_T = 2RT \log_e (d/D)$, which he deduced from different theoretical considerations. W. E. T.

2063. *Translation-energy of Liquid Molecules.* **G. Jäger.** (Akad. Wiss. Wien, Sitz. Ber. 110. 2a. pp. 1141–1145, 1901.)—This paper purports to give a simple proof of the proposition that the average translation-energy of the molecules of a substance in a saturated state is the same whether the phase is liquid or gaseous. It consists in showing [by the help of assumptions and approximations] that the saturation-pressure of a vapour depends especially, according to one calculation, on a factor $exp(-r\mathrm{J}/RT)$, where r is the latent heat of vaporisation and the other letters have their usual signification, and, according to another, on a factor $exp(-3a/mc^2)$, where a denotes the work required to transfer a molecule of mass m and speed c from the interior of a liquid to the interior of its vapour, and in identifying these two factors. Now $r\mathrm{J} = na$, if n is the number of liquid molecules in unit mass, and $RT = \frac{1}{3}nmc^2$ on the kinetic theory of gases, if n, m, c refer to *gaseous* molecules; hence $\frac{1}{3}nmc^2$ (and so c^2) is the same for molecules in both the liquid and the gaseous phase. The author then tacitly assumes that n is the same in both phases. R. E. B.

2064. *Application of the Phase-rule to the Melting-points of Copper, Silver, and Gold.* **T. W. Richards.** (Amer. Journ. Sci. 13. pp. 377–378, May, 1902.)—This is a theoretical note on the results obtained by Holborn and Day. The constant melting-point of 1,064° found for gold [see Abstract No. 810 (1901)] is due to the fact that gold does not dissolve or combine with the oxygen or nitrogen of the atmosphere. Silver, however, dissolves oxygen, and as there are accordingly two components and only three phases there is one degree of freedom. If a constant oxygen pressure were maintained a new condition would be imposed, and two components in three phases would suffice to produce an invariant system. But the great variation of the solubility of oxygen in silver with the temperature renders such a theoretically invariant system practically variable. The case of copper is very interesting. If copper be melted in air with full opportunity for oxidation, the temperature observed, 1,065°, is far more constant and trustworthy than the higher temperature of 1,084° which is obtained when air is rigidly excluded. In the former case there are two components, copper and oxygen, and *four* phases, namely, solid copper, solution of cuprous oxide in melted copper, liquid cuprous oxide, and vapour; hence an invariant system. The latter case corresponds to the simple invariant system, solid copper, liquid copper, and vapour. F. G. D.

2065. *Fundamental Equations of the Multiple-Point.* **P. Saurel.** (Journ. Phys. Chem. 6. pp. 261–264, April, 1902.)—Determinantal equations are given connecting the slopes of the $n + 2$ pressure-temperature curves which converge to an $n + 2$ multiple point, with the specific volumes, specific entropies and concentrations of the components which have been given by Riecke (Göttingen Nachrichten, p. 223, 1890; Zeit. Phys. Chem. 6. 268, 1890). Other forms of these generalised equations are considered in the present article. [See also Abstract No. 1354 (1901).] F. G. D.

2066. *Maximum External Work in Isothermal Evaporation.* **S. Meyer.** (Ann. d. Physik, 7. 4. pp. 937–941, April 8, 1902.)—Dieterici has pointed out [see Abstract No. 696 (1902)] that for every substance there must exist a temperature and pressure for which the external work performed along the two-phase liquid-vapour saturation curve in isothermal evaporation is a maximum, since for the (reduced) pressures $\pi = 0$ and $\pi = 1$ the above work is zero. From a comparison of existing experimental data Dieterici found the temperature corresponding to this maximum condition to be the same for all substances, namely, $\tau = 0{\cdot}77$, where $\tau =$ reduced temperature. It is pointed out by Meyer that this result is a necessary consequence of the lack of specific constants in van der Waals reduced equation, and he shows how to calculate the temperature and pressure corresponding to the maximum work curve by a tentative graphical method, making use of Maxwell's condition. In this way he shows that $\tau = 0{\cdot}700$. F. G. D.

REFERENCE.

2067. *Energy and Entropy of Mixtures.* **P. Koturnitzky.** (Jurn. Russk. Fisik. Chimičesk, Obščestva, 34. 2b. pp. 29–33, 1902.)—The exact expressions for the energy and entropy of a mixture of bodies in two states, as developed in this paper, have certain integral terms instead of g and t respectively in the ordinary expressions. A. G

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

2068. *Field of Force of an Electric Charge in Uniform Motion.* **H Bucherer.** (Ann. d. Physik, 8. 2. pp. 326–335, May, 1902.)—The author assumes the ether to be at rest, and regards all currents as displacement currents, a current being conditioned by motion of lines of displacement with reference to a system of axes fixed in the ether. The displacement is the sum of two parts, the first belonging to the ether alone and equal to the electric intensity, the second due to the presence of the dielectric. The author makes use of a vector F derivable from a scalar potential; it has been employed by Lorentz and by Searle, who have shown it to denote the mechanical force exerted by the moving charge on a unit charge taking part in the motion, while J. J. Thomson has proved that the components of electric and magnetic intensities can be expressed in terms of it. If the motion take place in the direction of x with velocity u ($< v$) and we write $\mu K v^2 = 1$ and $1 - (u^2/v^2) = s$ and refer everything to a co-ordinate system taking part in the motion, Thomson's results are $E_x = F_x$, $E_y = F_y/s$, $E_z = F_z/s$ for the electric intensity components, and $H_x = 0$, $H_y = -KuF_z/s$, $H_z = KuF_y/s$ for the magnetic. The author shows that if the charged ellipsoid (a, b, b) move with uniform velocity $u < v$ parallel to a in a medium of dielectric constant K, then the potential over the surface is equal to that over an ellipsoid a, $b\sqrt{s}$, $b\sqrt{s}$ at rest in a medium with constant $K/s = K'$, and that the expression for the whole energy of the moving ellipsoid remains correct when K, F_x, F_y, F_z are replaced by K', F'_x, F'_y, F'_z. A very important property of the function F is its symmetrical distribution with reference to a plane through the equatorial section of the ellipsoid; it follows that the electric intensity, the distribution of energy and the vector product EH are also symmetrical with reference to that section. W. S

2069. *Electrification and Rate of Evaporation.* **A. Pochettino.** (Accad Lincei, Atti, 11. pp. 376–380, May 4, 1902.)—A *résumé* is given of previous experiments. The author, measuring the rate of diminution in size in dry air of a drop perched on an electrified wire, finds that electrification retards evaporation feebly but sensibly. The surface-tension effect is not sufficient to account for the amount of retardation observed. No difference was found between positive and negative electrifications. A. D

2070. *Dispersion of Atmospheric Electricity in Austria.* **F. Exner.** (Gesell Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 3. pp. 231–237, 1902.)—Experiments conducted in the four stations of the Vienna Academy, at Vienna Trieste, Kremsmünster, and Innsbruck, in the first three by means of mechanically registering apparatus with the aid of radium-collectors, which agree well with a water collector (at Vienna). The observers are Conrad, E. Mazelle P. F. Schwab, and P. Czermak. The negative dispersion predominates at the first three stations, the positive at Innsbruck. The most complete work as to clouds, wind, and other features is done at Trieste. H. E

2071. *Dispersion of Atmospheric Electricity at Munich.* **H. Ebert.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 3. pp. 219–230, 1902. From the Physik. Institut der Techn. Hochschule at Munich.)—Experiments made by the author, C. W. Lutz, and C. Ruf in the open at Munich and on the Starnberg Lake, in a cellar, and in the laboratory, with apparatus of the author's and of Elster and Geitel. Earthing the roof of the apparatus affects the results. Abnormally high dispersions for negative electricity were observed on the swampy lake-shore, very low values in dense forests; before thunderstorms the values are very high. The cellar of 500 c.m. has no windows, and is only lighted by electric glow-lamps. The dispersion figures are very high; negatively charged and even electrically neutral wires became radio-active in the stagnant air, and insulated conductors assume negative charges. The laboratory tests concern dispersion in glass vessels filled with various gases and liquid air. H. B.

2072. *Dispersion of Atmospheric Electricity at Capri.* **J. Elster.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 3. pp. 193–218, 1902.)—Essentially tables of the results of the observations which V. Cuomo has been making since October, 1901, in a garden, situated on a cliff close to the sea on the island of Capri, generally at 1 p.m. in the shade, with apparatus of Elster and Geitel. The dispersion rate is high and about equally rapid for negative and positive charges. H. B.

2073. *Lightning Recorders and Thunderstorm Forecasts.* **J. Kenealy.** (U.S. Weather Bureau, Bull. 31. pp. 76-78, 1902.)—The author describes and illustrates the apparatus set up by Odenbach at the Jesuit College of Cleveland, Ohio, whose copper-covered steeple rises to a height of 150 ft. The apparatus consists of coherer with brass electrodes and powdered nickel and silver in a glass tube, and a sounder as decoherer, which also carries the recording style. Lightning has often been recorded by a short line nine hours before any thunder was heard. H. B.

DISCHARGE AND OSCILLATIONS.

2074. *Water-Vapour in Gaseous Electric Conduction.* **P. Lewis.** (Phil. Mag. 3. pp. 512–514, May, 1902.)—Trowbridge having expressed his conviction that pure gases, hydrogen especially, are perfect insulators, and that therefore water-vapour or oxygen are necessary to produce the dissociation upon which conduction depends, the author opposes that view partly on general grounds and partly from the evidence of his experiments with sodium in vacuum-tubes. He considers that in the cases tried by him no water-vapour or oxygen could be present. P. E. S.

2075. *Temperature of the Electric Arc.* **C. Féry.** (Comptes Rendus, 134. pp. 1201–1204, May 26, 1902.)—Since the temperature of the crater of the arc is independent of the current, it represents, according to Violle, the temperature of ebullition of the carbon. Its determination is therefore a matter of importance. By extrapolation of results obtained from various physical properties, values ranging from 3,500° to 4,100° have been obtained. The author, by application of Stefan's law, has obtained a result near the lower of these limits. To control this result measurements have been made with an im-

proved form of optical pyrometer, Chatelier's pattern. Assuming Wien's formula $I_0 = C\lambda^{-5}e^{\frac{C\lambda}{\theta}}$ as representing the radiation from a perfectly black body, the pyrometer is compared with a platinum-platinum rhodium couple between 1,100° and 1,500°. From these observations it appears that Wien's law is true within these limits. By extrapolation, the temperature of the arc is deduced from observations on it with the pyrometer, using a red and a green ray. These give the temperature as 3,867° and 3,897° respectively. As this was higher than the value deduced above, it was thought that impurities in the carbon affected the result. A repetition of the observations with graphitic carbon gave concordant values. The conclusion is therefore drawn that, at the temperature of ebullition, carbon does not behave as a perfectly black body. [See also Abstract No. 1700 (1902).] R. S. W.

2076. *Measurement of ϵ/μ in Kathode Rays.* **W. Seitz.** (Ann. d. Physik, 8. 2. pp. 233–243, May, 1902.)—The various methods which have been used to determine the value of $\mu v^2/2\epsilon$ in kathode rays are: The potential of discharge method of Kaufman and Simon; the electrostatic deflection method of Wien and Lenard; and the bolometric method of J. J. Thomson. The author in this research determines the value of $\mu v^2/2\epsilon$ by all three methods in one and the same tube, and compares the accuracy to be obtained by the three methods. The experimental results at potentials above 8,500 volts are given in tables in the paper. All three methods lead to the same result, but the bolometer method fails at lower potentials. The electrostatic deflection method is considered the simplest and most accurate. To determine ϵ/μ and v the magnetic deflection was also measured, and the results are given in the following table :—

V.	$\frac{\epsilon}{\mu} \times 10^{-7}$	$v \times 10^{-10}$
8490	1·90	0·572
9410	1·92	0·604
9740	1·89	0·603
10420	1·86	0·627
11040	1·85	0·640
11120	1·825	0·639
11580	1·885	0·661
12900	1·90	0·700
14700	1·82	0·730
15110	1·85	0·748
	1·87	

The mean 1·87 compares well with Simon's value, 1·865. J. B. H.

2077. *Reflexion and Secondary Emission of Kathode Rays.* **L. Austin** and **H. Starke.** (Deutsch. Phys. Gesell., Verh. 4. 6. pp. 106–126, March 21, 1902.)—A reflecting metal surface is placed in the path of the kathode rays produced by an influence machine, and is connected to earth through a galvanometer. When the rays strike the reflector perpendicularly, the galvanometer shows a negative stream, but if it is turned round an axis in its own plane, so as to increase the angle of incidence gradually, the earth

current decreases, becomes null, and may finally attain a positive value greater in actual magnitude than the initial negative current. The conclusion is drawn that the reflector itself becomes a source of negative electricity, this taking the form of a cloud of negatively charged particles, of the same order of magnitude and velocity as those forming the kathode rays. The experiments described in the paper show that this emission decreases with the velocity of the incident kathode rays, but is independent of the gas pressure. The greater the polish or the density of the reflecting metal, the stronger are the secondary rays; they are also increased by an increase in the angle of incidence. The density of the reflector and the percentage reflexion at normal incidence are nearly proportional, and at this incidence the reflecting power for the same metal appears to be independent of gas pressure and of the potential between the electrodes—at least within the limits 3,000–30,000 volts. R. S. W.

2078. *Reflexion of Kathode Rays.* **J. Stark.** (Deutsch. Phys. Gesell., Verh. 4. 8. pp. 167–182, April 25, 1902.)—The paper is chiefly a reply to criticisms by Austin and Starke [see preceding Abstract] on an earlier paper of the author's [see Abstract No. 1123 (1902). He arrives at the following conclusions: (*a*) The joint experiments of Austin and Starke contain nothing which is in contradiction to the theory he has advanced; (*b*) that in experiments on the reflexion of kathode rays, errors are usually made in neglecting the Volta currents between kathode and reflecting surface, the diffusion of the ions, and the secondary emission of the rays. R. S. W.

2079. *Electric Discharge in Flames.* **J. Semenov.** (Comptes Rendus, 134. pp. 1199–1201, May 26, 1902.)—A description of various experiments in which a spark from an induction coil is allowed to pass from one flame to another. As in Geissler tubes, a great dissymmetry with respect to the poles is noticed. The discharge starts from the anode, runs up the outer sheath of the flame, leaves it in a direction normal to it at that point, and stops about a centimetre from the negative flame. The obscure part of the first flame is thus rendered luminous up to the point where the discharge leaves it: above this point the outer sheath disappears entirely, giving rise to a thick deposit of carbon. As in tubes, the heating effect at the negative pole is considerably greater than at the positive. There appears to be a transport of material particles in the direction of the current. R. S. W.

2080. *Kathode Rays of Small Discharge Potential.* **E. Goldstein.** (Deutsch. Phys. Gesell., Verh. 4. 9. pp. 204–211, May 9, 1902.)—When kathode rays fall on a metallic surface, the author finds that they give rise to a species of secondary kathode rays, more deflectable than the primary. As the discharge potential and gas pressure are varied, these secondary rays go through numerous gradations, in some of which they strongly resemble the light of the positive column. R. S. W.

2081. *Theory of Spark-Telegraphy.* **A. Slaby.** (Elektrotechn. Zeitschr. 23. pp. 165–169, Feb. 27, and pp. 254–258, March 27, 1902. Abstract in the Electrician, April 25 and May 2, 1902.)—The author first gives the results of oscillation determinations, by means of a spark micrometer, in a straight wire connected to one electrode of an induction coil, the other electrode being earthed or connected to a large capacity. A standing wave was found, with potential loops at the ends and a relative node at the middle. The overtones

were negligible. When the electrode was connected with any other point than the end of the wire, a disturbed wave of similar character was obtained. The results of these and other experiments are in strict agreement with those obtained theoretically by M. Abraham [see Abstract No. 285 (1899)]. The law connecting the magnitude of the effect on the receiver with the distance from the transmitter was found by means of micrometer measurements to be that of the inverse distance. With a series of Leyden jars of known capacity forming, with a known length of wire, a closed circuit, except for the spark gap, Kirchhoff's formula was found to be in exact agreement with the experimental results. Kelvin's formula, given in 1853, in which the effect of capacity is neglected, gave values about 36 per cent. too high—a result which was to be anticipated. The character of the sparking had no effect on the wave-length emitted. [See also Abstract No. 1015 (1901).] G. W. DE T

ELECTRICAL PROPERTIES AND INSTRUMENTS.

2082. *Resistivity of Iron Alloys.* **W. F. Barrett.** (Roy. Soc., Proc. 69 pp. 480–485, April 4, 1902.)—In reference to the alloys mentioned in a previous research [see Abstract No. 1721 (1902)] the author traces a connection between the atomic weight of the alloying element and (1) the electrical resistivity, and (2) the specific heat of the alloy. He comes to the conclusion that, as far as his experiments go, the two properties mentioned decrease as the atomic weight of the alloying metal increases. P. E. S

2083. *Temperature Variation of Electrical Resistance.* **W. Williams** (Phil. Mag. 3. pp. 515–532, May, 1902. Paper read before the Physical Society.)—An attempt to show the relation of the specific electrical resistance σ for pure metals at 0° C. with the maximum chemical valency m, the atomic volume V, and the absolute melting-point T. The author shows that $\sigma = Km\mathrm{V}/\mathrm{T}$, where K is a quantity that has different values for different groups of metals; from this is derived $\sigma = Km\mathrm{V}\theta/\mathrm{CT}$, where $\mathrm{C} = \mathrm{V}^{\frac{1}{3}}\alpha\mathrm{T}$, α being the coefficient of thermal expansibility, and θ the absolute temperature; this relation roughly holds for silver, copper, magnesium, sodium, zinc, cadmium, calcium, potassium, platinum, palladium, thallium, lead, mercury, arsenic, antimony, and bismuth, but fails for gold, indium, tin, and aluminium. It also fails for iron, nickel, and cobalt, while in the case of the remaining metals data cannot be obtained to test the matter. If σ is the specific resistance at temperature t, and σ_0 at 0° C., there is a temperature factor—

$$\sigma/\sigma_0 = (1 + \epsilon t)[1 + \tfrac{1}{2}(\beta' - \delta')t + \ldots];$$

This is obtained from the proportionality of q to $nh/m\lambda$, where q is the average number of electrons dissociated per unit volume, n the average number of atoms per unit volume, h the average thermal energy of an atom at temperature θ or $\rho\theta$ (ρ being the atomic specific heat), and $\lambda = \mathrm{V}^{\frac{1}{3}}\alpha\theta$. This relation is approximately true of tin, copper, cadmium, zinc, silver, and aluminium, but not for platinum and palladium, nor for the metals of the iron group. There is a specific heat relation $\epsilon = 2.1\beta/w$; where ϵ is the average increase in the specific heat per unit rise in temperature, w the atomic weight and β from the following relation $\alpha = \alpha_0(1 + \beta t)$, the relation $\epsilon = 2.1\beta/w$ is approximately true for aluminium, copper, tin, cadmium, palladium, silver, iridium, and platinum, but not for metals of the iron group; the results are uncertain for lead, magnesium, and zinc; while in the case of the remainin

metals the relation cannot be tested. A further relation $\sigma_e/\sigma_s = \lambda_e/\lambda_s$, where σ_s is the value of σ in the solid state just before fusion has begun, σ_e its value in the liquid state when fusion is just completed, λ_e and λ_s being the values for λ corresponding to σ_e and σ_s. The ratio λ_e/λ_s is best calculated from the increase of volume that accompanies the fusion. This relation holds roughly true for lead, cadmium, tin, and zinc, the only metals for which, at present, it can be tested. E. C. R.

2084. *Mutual Inductance of a Circular Circuit and a Circuit with Two Parallel Infinite Straight Sides.* **G. F. C. Searle.** (Cambridge Phil. Soc., Proc. 11. pp. 398–406, May, 1902.)—Maxwell, in his Electricity and Magnetism, has shown how to find the mutual inductance of two circular circuits whose axes meet in a point and are inclined at an angle θ. The result is given in the form of a series whose typical term involves $P_n(\cos\theta)$, the surface zonal harmonic of nth order. The process employed by the author in the present case is identical in principle with that used by Maxwell for his circular circuits. His result is expressed in the form of a series involving the two angular co-ordinates, which determine the direction of the axis of the circular circuit relative to the two parallel sides of the other, in the form of surface sectorial harmonics. W. S.

2085. *Resistivity of Metallic Sulphide.* **J. Guinchant.** (Comptes Rendus, 134. pp. 1224–1226, May 26, 1902.)—The author endeavours to find some connection between metallic and electrolytic conduction by investigating the electrical behaviour of bodies apparently intermediate in properties—for example, the metallic sulphides, selenides, arsenides, phosphides, &c. These bodies are in general formed with slight production of heat, comparable with the heat evolution in the formation of alloys, have metallic lustre, and are, or can become, good conductors. The resistance of metals increases with the temperature, and that of electrolytic solutions decreases; conclusions as to the mode of conduction are often drawn from the sign of this temperature coefficient; but these are hardly legitimate, for certain highly resisting alloys of copper-manganese and iron or nickel and all the metalloids have a decreasing resistance with increasing temperature. On the other hand, certain electrolytic solutions, *e.g.*, HF and H_3PO_4 have coefficients of which the sign becomes changed below 100° C. It is known that the greater number of metallic sulphides, whether natural or prepared artificially, have resistances rapidly decreasing as the temperature rises. The author has determined the resistances at different temperatures of PbS, SnS, FeS, Cu_2S, sulphide of antimony and sulphide of silver. The sulphides were obtained by precipitation, and purified from accompanying sulphur by fusion. They were cast into rods 5 mm. in diameter and 7 cm. in length. A differential method was used in measuring the resistances; the sulphide was heated in a thick copper tube in a nickel wire electric furnace. The temperatures were measured by a platinum-platiniridium couple. Thermo-electric changes had no effect. The author gives tables of the resistivities of three characteristic sulphides:—Sulphide of lead (PbS): Very good conductor at ordinary temperatures. The resistance increases as the temperature rises, and the resistivity varies almost proportionately with the temperature. From $-25°$ C. to $+100°$ C.—

$$\rho t = 0{\cdot}000298(1 + 0{\cdot}00501t).$$

The curve gave indications of a minimum resistance at a temperature probably below $-100°$ C. Stannous sulphide (SnS): Bad conductor at ordinary tem-

peratures; resistance decreases with rise of temperature, but tends to become constant near the melting-point. From 0° C. to 100° C.—

$$\rho t = 1071(1 - 0{\cdot}00662t).$$

Ferrous sulphide (FeS): Fairly good conductor. The resistance diminishes at first until the temperature reaches 550° C.; it then increases, so that the value at 870° C. is the same as that at 200° C. The figures for FeS are as follows:—

HEATING.

t.....	13° C.	90°	130°	280°	350°	495°	580°	672°	868°
ρ.....	0·0998	0·0314	0·00826	0·00125	0·00102	0·00087	0·00087	0·00099	0·00171

COOLING.

t.....	868°	670°	580°	465°	350°	249°	130°	95°	8°
ρ.....	0·00171	0·00112	0·00099	0·00086	0·00079	0·00090	0·00605	0·0273	0·015

From 0° to 100° the resistivity is perhaps represented by—

$$\rho t = 0{\cdot}1114(1 - 0{\cdot}00798t).$$

The other sulphides studied resembled some one of the above, depending on the initial value of their conductivities. For all the velocity of variation of resistance increases continually with temperature in going from the neighbourhood of 0° C. The initial value is positive, and therefore remains positive, for good conductors; for poorer conductors it is first negative, and later changes its sign. The author concludes that "the sign of the coefficient of temperature depends on the value of the resistivity or the causes which determine it, and not on accessory phenomena, such as electrolysis, which may accompany the passage of the current." W. C. B.

2086. *Electro-calorific Effect in Tourmaline.* **R. Straubel.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 2. pp. 161–164, 1902.)—The experiments here described are the converse of the well-known pyroelectric phenomena observed in Tourmaline. The crystal is placed in an electric field and the thermal changes due to changes in the electric field are observed. Four plates 0·2 cm. thick were cut perpendicular to the axis of the crystal. The plates were laid one over the other in two pairs, one pair having the one pole of the crystal upwards, the other pair having the other. Between the two plates of one pair one set of junctions of a thermo-electric battery were placed, the other set of junctions being placed between the other two plates. The plates were then placed between the plates of a condenser which were 1·35 cm. apart, and could be charged to a difference of potential of 30,000 volts. On charging the condenser a deflection was observed on the galvanometer, which reached a maximum in half a minute, then sank in four minutes to zero. On reversing the poles of the condenser the deflection again took place, but in the opposite direction, and again fell to zero, and so on, the deflection being repeated after each reversal. The deflections obtained averaged 4·9 scale divisions. After turning one pair of crystalline plates, so that all the plates lay with their similar poles upwards, and repeating the experiment, the average deflection only attained to 0·1 scale divisions. The temperature variation corresponding to the greater deflection was $0{\cdot}74 \times 10^{-3}$ degrees Centigrade. J. B. H.

2087. *Maxwell's Law for some Nitrogen Compounds.* **E. van Aubel.** (Comptes Rendus, 134. pp. 1050–1052, May 5, 1902.)—Schlundt has published [see Abstract No. 522 (1902)] his measurements of the dielectric constants of a number of amines (primary, secondary, and tertiary), nitro-compounds (nitromethane and nitroethane), nitrates (ethyl, propyl and butyl), and nitriles (aceto-, propio-, valero-, and capro-); the author has taken from the tables of Dufet and Loevenherz the corresponding value of the indices of refraction for the above compounds, in order to see if the relationship between dielectric constant and index of refraction was that expressed by Maxwell's law, $n^2 = k$. In all four classes of compounds it was found that the dielectric constant diminishes as the molecular weight increases, while the index of refraction increases under the same conditions. D. H. J.

2088. *Oscillographs.* **A. Blondel.** (Journ. de Physique, 1. pp. 273–302, May, 1902.)—This paper is divided into two parts, of which the first describes the new models of oscillographs, and is illustrated by nine figures. The new models described are those with a soft iron strip, and with bifilar suspension. The second part deals with the mathematical theory of oscillographs, including the cases described in the first part. [See also Abstracts Nos. 1510 (1899), 167 (1900), and 1127 (1901).] E. H. B.

2089. *Curve-Tracing Instrument.* **R. B. Owens.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 753–759, May, 1902.)—The principle of this instrument is similar to that of a differential galvanometer, but instead of a needle a coil suspended by two thin phosphor-bronze strips, and carrying a current is used. The fixed coils are simply concentric circles of wire, the current whose wave-form is to be measured being sent through one, and a direct current through the other. This latter current is adjusted until there is no deflection of the suspended coil, through which periodic impulses of current are sent by means of a contact-maker. The direct current through the fixed coil is then read by a Weston ammeter. The advantages of this instrument are: (1) It makes use of a zero method; (2) the only instrument to read is a Weston ammeter; and (3) it has very small resistance and inductance. The following applications are given: tracing p.d. and current waves, finding the curves of the growth and decay of currents, obtaining the leakage coefficients of large generators, determining the variations of the angular velocity of engine flywheels during one revolution, and finding the fluctuations of current from commutating machines. A. R.

2090. *Telephotographic Apparatus.* **A. Korn.** (Elektrotechn. Zeitschr. 23. pp. 454–455, May 22, 1902.)—The transmitter of this apparatus, like all others intended to transmit the variations of intensity of a beam of light to a distance, uses the selenium cell. The novelty of this particular apparatus lies in the receiver, which consists of a vacuum tube, the light emitted from which varies with changes made in the circuit. These changes are brought about by the transmitter, the length of a spark-gap in series with the vacuum tube and a Tesla transformer, being made to vary with the current passing through the selenium cell. The spark-gap is arranged between a fixed electrode and one which is pivoted with the needle of a galvanometer so as to turn with the needle. The current from a battery is passed through the selenium cell and the coils of the galvanometer, and so the spark-length gives a measure of current in the galvanometer and in the selenium cell. Some photographs of simple geometrical forms having two and three shades have been reproduced. J. B. H.

2091. *Sensitiveness of the Coherer.* **E. R. Wolcott.** (University Wisconsin, Bull. 3. 1. pp. 1–20, Dec., 1901.)—After some preliminary historical notes, the author describes experiments recording the diminution in the resistance of coherers of aluminium, tin, lead, zinc, iron, copper, silver, nickel, platinum, and gold. He then investigates the effect of establishing various p.d.'s between the two sections of the coherer by means of a second battery. Finally, he studies the action of the coherer when the metals are coated with non-conducting films. He arrives at the conclusions that Guthe and Trowbridge's theory explains more facts than those of Branly, Lodge, and Bose; but that all four may be partially applicable, and that, of the above metals, aluminium is the most regular in response. The fact, observed by Marconi and others, that nickel gives the best results at long distances, he explains by the fact that it is found to have the lowest critical potential of the metals tried, and therefore responds to the smallest amount of energy, but when the intensity is sufficient to overcome the greater critical potential of aluminium, the latter gives better results than nickel, owing to the regularity of response depending on the metal itself. He therefore suggests that the best results would be attained by using a metal which shows the greatest regularity of response, coated with a medium which gives the lowest critical potential.
G. W. DE T.

2092. *Sensitive Coherer.* **E. Branly.** (Comptes Rendus, 134. pp. 1197–1199, May 26, 1902.)—The coherer consists of a tripod formed of a steel disc with three legs ending in blunt oxidised points, resting upon a polished steel disc. Decoherence is effected by the striking of the lower contact by the tongue of the relay. The tap may be very slight, and therefore the play of the tongue may be much reduced, with a corresponding increase in speed. The author finds this form very regular and reliable in action, and that it will continue in working order for several months. When transmitting a message, the tripod of the coherer at the sending station is slightly raised from the lower disc by means of an auxiliary electromagnet, and maintained in this position as long as the transmission continues. This prevents it from being effected by the transmitter sparks. [See also Abstract No. 1106 (1902).]
G. W. DE T.

2093. *Convenient Form of Vacuum Tube.* **W. B. von Czudnochowski,** (Phys. Zeitschr. 3. pp. 366–368, May 15, 1902. Also Zeitschr. f.d. physik. u. chem. Unterricht, 15. pp. 124–126, 1902.)—Some vacuum tubes made by Max Strehl are described here, which enable experimenters who are not skilled glass-blowers to study all the phenomena of kathode rays. The various electrodes are fixed to ground stoppers which fit into necks in a glass bulb, and a variety of electrodes are supplied for the standard experiments.
J. B. H.

ALTERNATING CURRENTS AND MAGNETISM.

2094. *Dielectric Constants Determined by Electric Waves.* **P. Drude.** (Ann. d. Physik, 8. 2. pp. 336–347, May, 1902, and Zeitschr. Phys. Chem. 40. pp. 635–637, May 13, 1902.)—In these determinations it is now found advantageous to introduce a Tesla transformer between the induction coil and the primary oscillator or wave generator. The whole apparatus is described and illustrated both diagrammatically and from a photograph, and is made by W. Schmidt.
E. H. B.

2095. *Hysteresis Loss in a Rotating Field.* **M. Schenkel.** (Elektrotechn. Zeitschr. 23. pp. 429–430, May 15, 1902.)—The author describes an experiment which is essentially a verification of the result first obtained by Baily, and confirmed by Beattie and Clinker, and Coran and Hiecke. A laminated iron core, 35 mm. in diameter and 17·5 mm. long, was rotated on a vertical shaft between the tapered poles of an electromagnet, by means of which the induction could be forced up to 28,000. The use of an ingenious form of suspension enabled the torque due to hysteresis and eddy-currents to be separated from that arising from friction; and by running at different speeds the hysteresis torque could be separated from the eddy-current one. The hysteresis loss was found to reach a maximum at B = 16,000, and beyond this value fell with extraordinary rapidity, appearing to approach a zero value asymptotically. A. H.

2096. *Magnetic Determination of Iron-Fields.* **R. Thalén.** (Öfvers. Kongl. Vet. Akad. Stockholm, Förh. 59. 5. pp. 175–189, May, 1902.)—The author shows how to detect the situation of an iron-field by means of magnetic measurements. Let G and F denote the vertical and horizontal components of the ore-magnetism respectively, V and H the corresponding elements of the terrestrial magnetism, P the overweight attached to, say, the south end of the needle, this overweight being chosen so that the needle will be horizontal on a field containing no ores; the inclination δ of the mining-compass on the horizontal plane in the meridian will be given by the formula $\tan\delta = (V + G - P)/(H - F) = G/(H - F)$. This shows that δ will be $= 90^\circ$ for H = F, which can occur only to the south or north of the south-pole of the iron-layer, but never vertically above this pole. Three different methods are then given of ascertaining the depth of the centre of gravity of the iron-layer. The rules given are next applied to a large series of measurements, the apparatus used being very fully described. A. G.

ELECTRO-PHYSIOLOGY AND ELECTRO-THERAPEUTICS.

2097. *The Effect of Electric Waves on the Human Brain.* **D. McIntosh** and **J. Graham-Willmore.** (Elect. World and Engineer, 39. pp. 952–954, May 31, 1902.)—An account of a series of experiments made to investigate the coherer-effect described by A. F. Collins [see Abstract No. 1116 (1902)] as occurring in fresh brain substance. The authors report they were unable to obtain any evidence to show that such an effect existed. Trials were made with the brains of animals before and after death, and with a human brain quickly removed from a recently dead person. H. L. J.

REFERENCES.

2098. *Three Dimensional Graphics.* **E. Hospitalier.** (Soc. Inst. Élect., Bull. 2. pp. 380–382, May, 1902.)—The author suggests, for the illustration of electrical problems depending on functions of three variables, the construction of wire models of the curves of double curvature involved. G. W. DE T.

2099. *The Rectified Alternate Current.* **C. Heinke.** (Phys. Zeitschr. 3. pp. 334–336, May 1, 1902.)—This is a note on the paper on the same subject by Gerschun [see Abstract No. 1547 (1902)]. The author gives a simpler method than that of Gerschun for considering the case of a transformer fed by such a current, obtaining also some additional results. W. S.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

2100. *Action of Hydrogen on Sulphide of Mercury.* **H. Pélabon.** (Chem. News, 85. pp. 172–175, April 11, 1902. Bull. Soc. Chim. Series, 3. 25. No. 16.)—Crystallised sulphide of mercury is slowly acted on by hydrogen at 280°. In order to study the reaction at higher temperatures, the author employed the method of rapid cooling previously described. [See Abstract No. 1732 (1902).] Excess of mercury being present, the quantity of sulphuretted hydrogen formed was found to tend towards a limit which did not depend on the pressure of the hydrogen or on the mass of the sulphide or mercury provided that they were not entirely vaporised at the temperature of the experiment. ρ being the percentage of the partial pressure of the sulphuretted hydrogen of the total pressure, the limits of ρ, 78·67, 85·29, 92·10 were found to be reached at the respective temperatures 360°, 440°, 540°, after heating for about 90, 14, and 4 hours. If excess of mercury be not present, it is calculated that for lower pressures than 416 mm., values for ρ ought to be obtained different from those for higher pressures, as the mercury set free will be in the form of a non-saturated vapour, and this conclusion is confirmed by experiment. The results obtained afford additional evidence in support of the equation $p_1p_2/p_3p_4 = f(T)$ [see Abstract No. 1121 (1900)], and the verification can be extended by examining the action of sulphuretted hydrogen on mercury. As the sulphide formed in this case can exist in the form of a non-saturated vapour, the limit value of ρ theoretically should be lower than when excess of sulphide of mercury is present, and experimental evidence for this is adduced. W. E. T.

2101. *Surface Tension of Liquid Precipitates.* II. **G. Quincke.** (Ann. d. Physik, 7. 4. pp. 701–744, April 8, 1902.)—Oily precipitates are formed by the action of carbon dioxide and of caustic alkalies on solutions of calcium nitrate, chloride and bicarbonate, which may last from 1–3 seconds or for some hours before solidifying. It is suggested that the formation of sphærocrystals in plants is due to the intermediate formation of similar liquid precipitates. [See also Abstract No. 1574 (1902).] T. M. L.

2102. *Oceanic Salt Deposits. Formation of Loewëite and its Lower Temperature-limit at 43°.* **J. H. van't Hoff** and **A. o'Farelly.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 19. pp. 370–375, April 10, 1902.)—Loewëite, $Na_2Mg(SO_4)_2 . 2H_2O$, occurs in the Stassfurt salt-beds, but, like langbeinite [see Abstract No. 1748 (1902)], cannot be produced at 25°. It can be formed from astrakanite above 71°, according to the equation—

$$Na_2Mg(SO_4)_2 . 4H_2O = Na_2Mg(SO_4)_2 . 2H_2O + 2H_2O.$$

In a solution saturated with sea-salts the transition-point for these two compounds is lowered to 43°, and this is probably the lowest temperature at which loewëite can have been deposited. T. M. L.

2103. *A Characteristic Salt in the Magdeburg-Halberstädt Salt-Beds.* **K. Kubierschky** and **J. H. van't Hoff.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 20. pp. 404–415, April 17, 1902.)—A mineral was found in the Wilhelms

hall pit in the Stassfurt salt-beds which on analysis gave very irregular results; but when these results were represented graphically they showed that the mineral was a mixture of two constituents, one of which was free from potassium. By extrapolation from the observed composition of samples containing various amounts of K_2SO_4, the composition of a mineral free from K_2SO_4 was deduced, viz., H_2O — O, $MgSO_4$ — 22, Na_2SO_4 — 78 mols. per cent. The one constituent is therefore an anhydrous salt, and has the composition $3Na_2SO_4 . MgSO_4$. For this new mineral the name Vanthoffite is proposed. The second constituent is a hydrated salt containing K_2SO_4, and may be either $3K_2SO_4 . 4MgSO_4 . 6Na_2SO_4 . 8H_2O$, or (by further subtracting $MgSO_4 . 3Na_2SO_4$ and dividing by 3) $K_2SO_4 . MgSO_4 . Na_2SO_4 . \frac{2}{3}H_2O$. In attempting to prepare the salt $MgSO_4 . 3Na_2SO_4$ synthetically a new anhydrous double salt was prepared having the composition $2K_2SO_4 . Na_2SO_4$. Vanthoffite can be prepared synthetically in two ways. (1) It is a final dehydration product of sodium magnesium sulphate; an equimolecular solution of Na_2SO_4 and $MgSO_4$ deposits at 22° crystals of astrakanite $Na_2Mg(SO_4)_2 . 4H_2O$, which changes at 70° to loeweite $Na_2Mg(SO_4)_2 . 2H_2O$, and at a slightly higher temperature to the anhydrous salt $3Na_2SO_4 . MgSO_4$, the excess of $MgSO_4$ remaining in solution. (2) It is more readily prepared by dehydrating a mixture of astrakanite and sodium sulphate by bringing them into contact with a solution of low vapour tension, $Na_2Mg(SO_4)_2 . 4H_2O + 2Na_2SO_4 - 4H_2O = MgNa_6(SO_4)_4$; a solution saturated with astrakanite and sodium sulphate and also with sodium chloride and glaserite has the composition—

$$1000H_2O + 42Na_2Cl_2 + 8K_2Cl_2 + 16MgSO_4 + 6Na_2SO_4,$$

and affords the best method of preparing the new mineral. T. M. L.

2104. *So-called Liquid Crystals.* II. **G. Tammann.** (Ann. d. Physik, 8. 1. pp. 103–108, April 29, 1902.)—With regard to the formation of so-called liquid crystals by cholesteryl benzoate, *p* — azoxyphenetol, &c., the author reiterates the view he has previously expressed on the subject, and further points out that the existence of crystals with a displacement elasticity equal to zero would introduce a fundamental modification of the space-net theory, if it did not, indeed, require its complete abandonment. Further experiments are described which support the view that such liquid crystals must really be regarded as emulsions. [See also Abstract No. 1352 (1901).] T. H. P.

2105. *Liquid Gold Hydrosolutions.* **A. Gutbier.** (Zeitschr. Anorg. Chem. 31. 4. pp. 448–452, 1902.)—The author has obtained chemically pseudo-solutions of gold of a blue colour of great stability, by reducing dilute neutral gold chloride solutions with hydrazine hydrate solutions. Necessary precautions are enumerated, and it is pointed out that by the same method numerous elements may be transformed into the colloidal state. A. G.

2106. *The Direct Combination of Chlorine with Carbon.* **R. Lorenz.** (Zeitschr. Elektrochem. 8. pp. 203–204, April 10, 1902.)—In connection with W. von Bolton's [see Abstract No. 1758 (1902)] research on the direct combination of chlorine with carbon, the author points out that he had already, in 1888, shown that it might be a source of error in the determination of carbon in steel by the so-called Wöhler method. The steel is heated in a current of chlorine, iron chloride volatilises, and carbon is left behind as an extremely fine powder. At a red heat this very finely divided carbon combines with

chlorine. Further the author has observed a direct combination in the preparation of boron trichloride by passing chlorine over a heated mixture of carbon and boron trioxide. Long white hair-shaped crystals were obtained which had the melting-point of hexachlorbenzene. Further, a direct combination has been noticed in the electrolysis of fused halogen compounds with a suitably high temperature and current density. W. C. B.

2107. *Velocity of Reaction between Amines and Nitrous Acid.* **H. Euler.** (Öfvers. Kongl. Vet. Akad. Stockholm, Förh. 59. 4. pp. 111–125, April 9, 1902.)—The action of nitrous acid on aromatic amines is of the first order, while that on fat amines is of the second order, the velocity of reaction being much smaller. A. G.

2108. *Elimination of Silicon in the Acid Open Hearth.* **A. M'William** and **W. H. Hatfield.** (Iron and Steel Institute, Journ. pp. 1–11, May, 1902.)—The proportion of silicon in open-hearth steel is closely related to the percentage of silica in the slag, and this largely without reference to the percentage of carbon and manganese in the metal. A thin slag containing about 51 per cent. SiO_2 gives a very low silicon steel, a slag containing about 54 per cent. SiO_2 gives a medium steel, and a thick slag containing 57 per cent. SiO_2 gives a steel high in silicon. This conclusion was fully confirmed by two experimental "heats" in which the proportion of silicon was first reduced in contact with a thin slag, was then allowed to rise as the slag took up silica from the hearth and thickened, and finally was again reduced by the addition of basic material to the slag; in each case the percentage of carbon was steadily falling during the whole "heat." A rise of temperature appears to favour the retention of silicon by the iron, but this is very possibly due to the increasing absorption by the slag of the silica of the hearth. T. M. L.

2109. *Behaviour of Oxygen and Hydrogen in presence of Water.* **A. Marcacci.** (Accad. Lincei, Atti, 11. pp. 324–326, April 20, 1902.)—In the present preliminary note it is shown by simple experiments in which the gases are confined over water, that oxygen and hydrogen combine at the ordinary temperature in presence of water. Some experiments leading to the same conclusion were announced to the International Physiological Congress at Turin in September, 1901. D. H. J.

2110. *Permeability of Animal Membranes.* **G. Galeotti.** (Zeitschr. Phys. Chem. 40. pp. 481–497, April, 1902.)—Animal membranes in contact with solutions vary in the readiness with which they permit the passage of dissolved substances in one direction or another. For the study of the subject the author chose the method of examining the change of resistance of an electrolytic cell due to the introduction of the membrane midway between the electrodes. The electrolytic cell was made in two parts, each part consisting of a piece of glass tubing (5 cm. long and 14 mm. through) sealed at one end and open at the other; the open ends were ground so as to fit closely together to form the complete cell. Platinum electrodes of nearly the same diameter as the cell were placed at $\frac{1}{2}$ cm. from the ground surfaces. Resistances were determined by Kohlrausch's telephone method. For each solution (common salt, potassium oxalate, &c.) the resistance of the filled electrolytic cell was first determined; the membrane was then placed on a silver ring and the ring was slipped over the end of one half of the cell; the ground end of the other half of the cell was then brought against the membrane and the resist-

ance was again determined ; the determination was repeated at intervals. In order to study dead membranes the latter were, in many cases, exposed on the silver ring to chloroform vapour ; the membranes showed microscopically no sign of structural alteration. The membranes employed were from (*a*) sheep intestines (freed from fat by treatment with ether, alcohol, and water), (*b*) the pericardium of the dog, (*c*) the mesenterium of the rabbit, (*d*) the bladder of the tortoise, (*e*) the cœcum of the rabbit, (*f*) holothuria intestines. The solutions used were equivalent, and also approximately isotonic with the solutions which naturally come in contact with the membranes. The experiments show that inactive membranes (*a*) offer but little resistance to the passage of the different ions, and the permeability does not alter by contact with the solution. Living membranes of a structure such as we find in the mesenterium and pericardium, (*b*) and (*c*), also show considerable permeability, which is little affected by the death of the cells ; these membranes act merely like ordinary diffusion membranes, and, in accordance with their natural functions, do not possess the property of resisting the forces which determine the migration of the ions. Other living membranes, which consist of specifically differentiated epithelial cells, and are destined to live in solutions varying in kind and in concentration, behave differently with different electrolytes ; some membranes favour the passage through the cell protoplasm, others oppose it. This selective action is a specific property of the living cell, and disappears with the death of the cell (either from the poisonous action of the solution or by the action of chloroform). The author gives a bibliography of recent work. D. H. J.

2111. *Densities of Mixtures of Hydrazine and Water.* **J. W. Dito.** (Konink. Akad. Wetensch. Amsterdam, Versl. 10. pp. 838–840, April 19, 1902.)—An investigation of the densities of mixtures of hydrazine and water was particularly interesting, as it results from Curtius's researches that hydrazine, when separated from aqueous solutions of its salts by the action of bases, will always be fixed on water, distillation giving a definite hydrate corresponding with the formula $N_2H_4 - H_2O$. The author tests the whole of the system hydrazine + water, it being shown that the curve of densities presents a maximum corresponding to the composition $N_2H_4 - H_2O$. The analogy with the behaviour of the system $SO_3 + H_2O$, as studied by Knietsch, is pointed out, contraction taking place in both cases on solution. A. G.

2112. *Union of Hydrogen and Oxygen.* **H. B. Baker.** (Chem. Soc., Journ. 81. and 82. pp. 400–406, April, 1902.)—The recognition of the fact that moist hydrogen and oxygen slowly combine in sunlight, made it advisable for the author to repeat some of his experiments on the union of dry hydrogen and oxygen, since it is conceivable that in the former experiments, in which the mixed gases were dried in the light, the rate of the continued production of water in the light might be equal to the rate of its absorption by the drying agent. In the present experiments specially pure hydrogen and oxygen were obtained by the electrolysis of barium hydrate, and the mixed gases were dried in the dark. It was found that the dried gases undergo no change in sunlight or at the melting-point of silver, and do not explode on heating to redness. There is no contraction observable on drying a gas from the point at which moisture ceases to exert any measurable tension to the point at which the gas ceases to be chemically active ; this was verified for hydrogen, oxygen, nitrogen, air, and for a mixture of hydrogen and oxygen, so that the dissociation of gases in the undried condition, if it exists, is too small to be detected by volume measurements. D. H. J.

2113. *Stability of the Equilibrium of Univariant Systems.* **P. Saurel.** (Journ. Phys. Chem. 6. pp. 257–260, April, 1902.)—Proofs are given of the following two theorems due to Roozeboom : I. Consider at the temperature and pressure of a multiple point a reversible variation which *increases* the entropy of the invariant system, the volume remaining constant. If during this process the mass of the *i*-th phase *increases*, then that invariant system in which the *i*-th phase is lacking cannot exist in stable equilibrium at temperatures *higher* than the multiple point. If the mass of the *i*-th phase *diminishes*, then the invariant system which does not contain this phase cannot exist at temperatures *lower* than that of the multiple point. II. Consider similarly a reversible variation in which the volume of the invariant system *diminishes*, the entropy remaining unchanged. If the mass of the *i*-th phase *increases*, then the corresponding invariant system cannot exist in stable equilibrium at pressures *higher* than that of the multiple point ; if it *diminishes*, then the corresponding invariant system cannot exist at pressures *lower* than that of the multiple point.

F. G. D.

2114. *Equilibrium Between a Solid and its Saturated Solution at Various Temperatures.* **J. S. Lumsden.** (Chem. Soc., Journ. 81. and 82. pp. 363–372, April, 1902.)—The solubility-curve of calcium propionate, which is convex to the axis of temperature, is regarded as exhibiting the typical form. The factors which determine solubility are stated to be three : (1) The thermal energy of the solid increasing rapidly as the temperature rises ; (2) the affinity between solvent and solute, decreasing as the temperature rises ; and (3) the opposing force of osmotic pressure, increasing as the temperature rises. These are represented in a diagram, and the resultant is a solubility curve similar to that of calcium propionate. The heat of solution of a solid usually decreases as the solution becomes more concentrated, and if positive in dilute solution may become zero and finally negative in a concentrated solution ; the heat of solution of a solid in a supersaturated solution may be determined by noting the heat absorbed or liberated in the reverse process of crystallisation from the supersaturated solution. Experiments with calcium propionate ($+ 1H_2O$) showed that at 12·4° the addition of successive quantities of 2½ grams of the salt to 25 grams of water produced a rise of temperature of 3·5°, 2°, 1·4°, 0·9°, and 0·6°. The heat of solution also diminishes usually with rise of temperature. At 10° the dissolution of 10 g. calcium propionate in 25 g. water raised the temperature 9·2°, whilst at 85° the rise of temperature was less than 1°.

According to the views put forward a solubility increasing or decreasing continuously with temperature represents a case in which only one branch of the solubility curve lies within the limits of experiment, and if the proper experimental conditions could be reached every curve would exhibit a minimum. A curve concave to the axis of temperature, and exhibiting a temperature of maximum solubility, is probably impossible ; such concave curves have occasionally been described, but probably in each case the intersecting convex curves of two hydrates have been mistaken for a single curve, the point of transition being overlooked. This has been found to be true for barium acetate and calcium isobutyrate, which have been stated to give solubility curves concave to the axis of temperature. T. M. L.

2115. *Comparative Study of Low-Carbon Steel Alloys.* **J. A. Mathews.** (Iron and Steel Institute, Journ. pp. 1–40, May, 1902.)—An iron was prepared by melting bar-iron (C = 0·4 per cent., P = 0·0066, Si = 0·068, S = 0·0056,

Mn = 0·025) with hæmatite, and on analysis gave C = 0·035 per cent., Si = 0·093, P = 0·0093; it was thus almost free from carbon, and contained only traces of other substances. Alloys of this iron were prepared by melting with chromium, manganese, molybdenum, tungsten, and nickel; in almost every case the resulting alloys contained less than 0·2 per cent. of carbon.

The dissolution of the iron in 10 per cent. hydrochloric acid is hindered by alloying with Cr and Ni and most of all by Mo. The tensile strength and elastic limit of the iron are increased by the addition of nickel, more so by the addition of chromium, and most of all by the addition of molybdenum; annealing reduces the T.S. (especially of the high-chromium alloys) and elastic limit, but increases the elongation and reduction per cent. of the test-pieces. The conductivity measurements gave results in general agreement with those of Barrett, Brown, and Hadfield, but in accordance with the greater purity of the materials used the conductivities observed were higher throughout. T. M. L.

2116. *Thallium-Sesquioxide Alums.* **A. Piccini** and **V. Fortini.** (Zeitschr. Anorg. Chem. 31. 4. pp. 451–454, 1902.)—The authors have succeeded in obtaining perfectly homogeneous mixture crystals of ammonium alum where part of the aluminium is substituted by thallium, this substitution occurring at variable ratios. They state that aluminium under anomalous conditions will give some compounds given by thallium under normal conditions. Indium, in this respect, also shows an intermediate behaviour. These experiments tend to confirm the perfect analogy between those elements, which consequence of the periodic system has recently been questioned by Locke. [See Am. Chem. Soc. Journ. 27. p. 280, 1902.] A. G.

2117. *Decomposition of Mercurous Chloride by Dissolved Chlorides.* **T. W. Richards** and **E. H. Archibald.** (Zeitschr. Phys. Chem. 40. pp. 385–398, April, 1902.)—In presence of hydrogen chloride or metallic chlorides, mercurous chloride is converted into mercuric chloride and so brought into solution in the manner expressed by the equation $Hg_2Cl_2 = HgCl_2 + Hg$. In solutions of equivalent strength hydrogen chloride and sodium chloride have approximately the same effect, barium chloride is less active and calcium chloride produces practically no effect. The amount of mercury dissolved increases with the concentration of the soluble chloride, but reaches a maximum at about 7 equivalents per litre of calcium chloride or 8 equivalents of hydrogen chloride. The influence of the soluble chloride may be explained by supposing that a double salt or mercurichloride is formed similar to the platinichlorides; this may be more or less ionised in accordance with an equation such as—

$$2NaCl + HgCl_2 \rightleftarrows Na_2HgCl_4 \rightleftarrows 2\overset{+}{Na} + \overset{-}{HgCl_4},$$

whilst if entirely ionised its formation might be represented by the simple ionic equation $2\overset{-}{Cl} + HgCl_2 = \overset{-}{HgCl_4}$ or $2\overset{-}{Cl} + Hg_2Cl_2 = Hg + \overset{-}{HgCl_4}$. The facts are best explained by supposing that the double salt is only partially ionised. The corresponding reaction takes place to a still greater extent in the case of the bromides and iodides, but not in the case of the sulphates. T. M. L.

2118. *Transference of Polarisation through Metallic Plates.* **W. Nernst** and **A. Lessing.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 2.

pp. 146–160, 1902. From the Universitäts-Institut für Physik. Chemie a Göttingen.)—The authors have investigated the question whether oxidising and reducing agents can exert their actions through platinum and palladium plates. It was possible that such action, if it existed, might escape detection by chemical means, and the authors therefore conducted experiments (similar to those of Root and Helmholtz in 1876) in which the change of potential on the outer side of the metal plate was examined from time to time after polarisation. From these experiments it appears that (1) if a reduction-potential is communicated (by electrolysis, by direct action of hydrogen gas or of a reducing agent) to one side of a palladium plate, the hydrogen with which the plate is charged migrates through the plate: such migration is governed by the laws of diffusion; (2) for oxygen no such diffusion could be detected; (3) with platinum there was no diffusion either of oxygen or hydrogen. D. H. J.

2119. *Voltaic Polarisation.* **Berthelot.** (Comptes Rendus, 134. pp. 865–873, April 21, 1902).—The author discusses electrolytic decompositions in which secondary reactions, independent of the electrolysis, take place. Experiments are described which show that the oxygen of the air exerts no immediate influence on the polarisation. In liquids to which pyrogallol has been added, the absorption of the atmospheric oxygen does not play an appreciable part in the production of the electromotive force which results entirely from the internal chemical reactions of the cell; this is, however, not quite the case if the liquid is violently shaken up in presence of oxygen. The effects produced by the addition of compounds of an acid nature, such as phenol, are also discussed. T. H. P.

2120. *Retrograde Diffusion of Electrolytes.* **J. Thovert.** (Comptes Rendus, 134. pp. 826–827, April 14, 1902.)—If we allow a solution of an acid to which another electrolyte has been added, to diffuse in presence of a quantity of this additional electrolyte, we find that the added electrolyte, though distributed at first uniformly through the whole liquid, becomes unevenly distributed after the experiment has proceeded for some time. The following table gives the details of the experiments, which were conducted in diffusion cylinders. At the end of an experiment the contents of the cylinder were removed in three separate portions (upper, middle, and lower) and analysed :—

Acid.	Added Salt.	Duration of Experiment.	Concentration of	In thirds.		
				Upper.	Middle.	Lower.
0·4HCl	0.39NaCl	16 h.	NaCl	0·384	0·390	0·395
,,	,,	47	,,	0·373	0·380	0·405
1HCl	0·39KCl	47	KCl	0·363	0·392	0·413
,,	,,	143	,,	0·350	0·401	0·425
0·5HNO_3	0·5$AgNO_3$	10	$AgNO_3$	0·48	0·49	0·52
,,	,,	50	,,	0·47	0·49	0·54
$\frac{1}{2}H_2SO_4$	1·03HCl	52	HCl	1·07	1·01	0·98

These results are explicable by Nernst's electrolytic theory of diffusion. If, in addition to the diffusing body, HCl, for instance, there is another uniformly distributed body—say, NaCl—present, we get diffusion as usual, in consequence of osmotic pressure, but the compensating electric force acting on the ions of the added electrolyte will be less than if the HCl alone were present. Con-

sequently there will be an increase of speed for the H ions (as shown experimentally by Arrhenius) and a retrogradation of the Na ions as shown above. D. H. J.

2121. *Manufacture of Caustic Soda and Bleaching Powder.* **J. G. A. Rhodin.** (Elektrochem. Zeitschr. 9. pp. 4-7, April, 1902. From the "Teknisk Tidschrift.")—The paper forms part of an address delivered by the author to the Society of Swedish Technologists, and contains an account of the author's arrangement (patented in England in 1896 and in Sweden in 1897) for the electrolysis of sodium chloride and the subsequent production of sodium hydrate and bleaching powder. The apparatus consists of an inner vessel, containing the salt solution floating on mercury; the mercury is in communication with an outer vessel containing water. The mercury forms the negative electrode, so that the sodium liberated during electrolysis first forms sodium amalgam, which by agitation is brought into contact with the water in the outer vessel; sodium hydrate free from chloride is thus obtained in the outer vessel, whilst chlorine is given off from the anode placed in the inner vessel. The author, after pointing out that the present supply of sodium hydrate and bleaching powder does not keep pace with the demand, gives details of working expenses to show that the present process is financially satisfactory. D. H. J.

2122. *Alternate-Current Electrolysis.* **E. Wilson.** (Electrician, 48. pp. 1025–1026, April 18, 1902.)—As alternate currents are employed in rail-returns for electric traction, the investigation of the electrolytic effects of alternate currents has become of practical importance, especially in the case of lead, which is extensively employed in underground work. An alternating current of density 0·024 amperes per sq. cm. and frequency 89 per second was passed for seven hours between two parallel plates of commercial lead 0·317 apart, immersed in dilute sulphuric acid. At the beginning of the experiment, while the plates were still bright, a curve of the potential difference was obtained between one of the plates and an exploring platinum electrode introduced halfway between the plates; simultaneously a curve of current was obtained by finding the instantaneous value of the potential difference between the ends of a non-inductive resistance placed in the circuit. These observations were repeated at the end of the experiment, using the same frequency, and the results plotted as a cyclical curve, the area of the curve representing the work spent upon electrolytic hysteresis, as, with the current densities employed, the potential difference due to conductivity of the electrolyte is negligible. A curve of similar form was obtained for frequency 23·3 per second, and current density 0·007 amperes per sq. cm. The ratio of the area of the first curve to that of the second was 0·854 to 1. A considerable amount of $PbSO_4$ was formed, so that the experiments were repeated with pure lead plates, using a current of 0·024 amperes per sq. cm. and frequencies 92·5 and 21·5. The diminution in weight was nearly twice as great at the lower frequency as it was at the higher, and the cyclical curves were of the same form, and the ratio of their area 0·22 to 1. This shows that frequency plays an important part in the reaction; the effect is entirely due to the current, as plates immersed in the same electrolyte when no current is passing are only slightly discoloured. Experiments were also conducted with aluminium plates in a solution of alum. The effect of the film of basic aluminium sulphate formed is very marked with alternating currents [see Abstract No. 1358 (1898)]. Two aluminium and two iron plates of equal areas and the same

distance apart were placed in alum solutions of equal strengths, with a current of frequency 17 and density 0·0169 amperes per sq. cm.; the maximum volts between the aluminium plates were 46, and between the iron plates 1·3.

A table of results is given :—

Data from Curves.	Commercial Lead.	Pure Lead.	Pure Lead.
Frequency in periods per sec....	89·0	92·5	21·5
(1) At beginning of experiment :—			
Max. coulombs	0·0095	0·0094	0·0394
Energy dissipated per plate per period in joules	0·0226	0·021	0·1122
Average watts per plate.....	2·13	1·94	2·42
(2) At end of experiment :—			
Max. coulombs	0·00947	0·0090	0·0406
Energy dissipated per plate per period in joules	0·0226	0·0316	0·1245
Average watts per plate.....	2·13	2·92	2·88

W. C. B.

2123. *Alkaline Earth Arsenides.* **P. Lebeau.** (Annal. Chim. Phys. 25. pp. 470–483, April, 1902.)—Arsenides of the metals of the alkaline earths of the type AS_2R_3 are readily obtained by the reduction of the corresponding arsenates by means of carbon in the electric furnace. These compounds are hence possessed of great stability, and are also very active chemically.

T. H. P.

REFERENCES.

2124. *Influence of Dissolved Salts on the Vapour Pressure of Aqueous Ammonia Solution.* **E. P. Perman.** (Chem. Soc., Journ. 81. and 82. pp. 480–489, May, 1902.)—[See also Abstract No. 1738 (1901).] D. H. J.

2125. *Physical Constants of Telluretted Hydrogen.* **de Forcrand** and **Fonzes-Diacon.** (Comptes Rendus, 134. pp. 1209–1212, May 26, 1902.) D. H. J.

2126. *A New Induced Oxidation.* **A. Job.** (Comptes Rendus, 134 pp. 1052–1054, May 5, 1902.) D. H. J.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

2127. *Breaking of Shafts at Critical Speeds.* **J. Frith** and **E. H. Lamb.** (Inst. Elect. Engin., Journ. 31. pp. 646–667, March, 1902.)—Various cases are on record of the failure of engine and dynamo shafts at some particular speed, which could not be explained by the effect of ordinary working strains, and suggested that the free period of some oscillations of the crank-shaft together with the attached masses, synchronised with the period of some external periodic force acting on the system. The authors show that absolute synchronism of these two periods is not essential to produce fracture, but that when the two periods approach within certain limits, there is great risk of fracture. They also show that the fractures can be avoided by a suitable adjustment of the stiffness of the shafts, and by some alteration in the moments of inertia of the revolving masses. A number of cases are investigated and solutions worked out in the paper and an appendix. The authors point out that an exact calculation of the periods of free motion is impossible, and recommend that in the design of plants these calculations should be applied to the shafts; and, in the event of the results giving periods of at all the same magnitude as the period of the engine beats, the shafts should be properly stiffened until all chance of synchronism is out of the question, and the forced amplitudes, which exist under all conditions, become small enough to produce no injurious effects. G. W. DE T.

2128. *Torsional Vibrations of Shafts.* **L. Gümbel.** (Inst. Naval Architects, Trans. 41. pp. 138–153, 1902. See also Engineering, April 11, 1902.)—In this paper, which was inspired by the one referred to in the preceding Abstract, the author, after referring to the work of Bauer [Jahrbuch der Schiffbautechnischen Gesellschaft. 1. 1900], Lorenz [Dynamik der Kurbelbetriebe, Leipsic, 1901], and Frahm [Verhand. der Gesell. deutscher Naturforsch. und Aerzte, Hamburg, 1901], applies Fourier's analysis to the problem, on the assumption of a proportionality between turning moment and angular velocity which is always applicable in the case of engine-driving dynamos, as well as in the case of marine and most other engines. The conclusions drawn from the results of the investigation are that: (1) The force with which the engine acts on the shaft should be kept as uniform as possible. (2) The continued application of revolutions of the engine which bear a simple ratio to the frequency of the natural vibration of the shaft should be avoided. (3) The possible tangential force diagrams should be determined for that number of revolutions likely to be adopted in practice which is most exposed to vibration; and it should then be ascertained, by the aid of the simple formulæ given in the paper, whether the resulting distortion of the shaft will remain within admissible limits. G. W. DE T.

2129. *Construction and Inspection of Steam Boilers.* (Frank. Inst., Journ. 153. Discussion, pp. 321–340, May, and pp. 431–450, June, 1902.)—This discussion was principally confined to the causes of the explosion of the loco-type boiler in the steamer *City of Trenton*, the questions of inspection and of construction of steam boilers generally not being dwelt upon. S. M.

Vauclain held that the accident was caused by overheating of the crown sheet from shortness of water, the flame having been directed upon one portion of that plate by a bridge. The overheated part sagged between the the stay-bolts, disengaging the screw threads by which they held up the plates, and throwing the strain on the rivet heads, which could not support it. **W. B. le Van** opposed that view, and maintained that the elongation of the stay-bolt holes and stripping of the threads were effects and not causes of the explosion, and that the threads were of too coarse a pitch originally. **J. M. Hartmann** blamed the faulty construction of the stay-bolts, and suggested improvements. **R. D. Kinney** suggested that the steamer having a list to one side would account for a portion of the crown plate being denuded of water long enough to become overheated, the position and appearance of the safety plug favouring this view. **G. B. Hartley** instanced the collapsing of furnace flues in marine boilers from overheating (although there was not shortness of water) caused by a coating of oil becoming deposited on the plate surfaces, and elicited the fact that oil was present in the *City of Trenton*'s boilers. **S. M. Vauclain** made some suggestions for an improved construction of the boiler, and **J. M. Hartmann** advanced some reasons for alteration of the existing procedure in boiler inspection. F. J. R.

2130. *Pulverised Fuel for Power Plants.* **F. G. Gasche.** (Railroad Gazette, 34. pp. 466–467, June 20, 1902.)—The author maintains that only the cost of pulverising has hitherto hindered the economical use of powdered fuel, but that modern methods have greatly improved that aspect of the industry. [See Abstracts Nos. 2232 (1901) and 543 (1902).] Results of comparative tests with the same coal used in hand-fired and dust-fired boiler furnaces are given in tables, and show 71·8 per cent. efficiency of boiler and furnace with dust fuel and 52·2 per cent. for hand firing.

The saving in fuel required to evaporate 5,175 lbs. of water from and at 212° F. was 10·75 per cent. by the dust-fuel method. F. J. R.

2131. *Losses from Back Pressure in Exhaust Steam-heating Systems.* **R. L. Gifford.** (Eng. News, 47. p. 453, June 5, 1902.)—The economical use of exhaust steam for heating buildings is limited by the amount of back pressure put upon the engine. One instance is quoted of an engine which developed 300 h.p. from 80 lbs. boiler pressure, or about 35 lbs. mean effective pressure at one-fourth cut-off, there being 8 lbs. back pressure caused by the heating system. In the absence of that back pressure 389 h.p. could have been obtained, so that the loss of power due to back pressure was 23 per cent. An equivalent quantity of live steam, if used direct in heating pipes, could have heated a six-storey building 75 ft. by 100 ft. in severe weather. If the steam could be circulated through the pipes at atmospheric pressure, the loss would be avoided, and even the effects of a condenser could be realised at times. These losses can be avoided by proper designing and ample pipe area. F. J. R.

2132. *Feed Regulator.* **D. Bellet.** (Locomotion Automobile, 9. pp. 394–395, June 19, 1902.)—A combined fuel and water regulator for steam boilers is described. It consists of a cylinder with a piston and vertical piston rod, the lower portion of which is coned and passes through a cone-seated hole in the cylinder cover leading to a chamber closed by a gland round the piston at its upper end. The feed-water is pumped into the cylinder above the piston and normally passes up through the cone-seated hole around the piston,

thence into the chamber above the cylinder and out through a ball valve into the boiler. By means of a branch pipe the boiler is also in connection with the portion of the cylinder below the piston, and by means of a system of levers actuated from the piston rod, the position of the piston is caused to control the fuel supply to the boiler furnace. If too much water is being pumped the piston is depressed and more fuel passes to the furnace, the boiler pressure rises and also the pressure below the piston of the regulator cylinder, which, being again forced upwards, closes the water passage round the piston rod and reduces the fuel supply until equilibrium is again restored.

C. R. D'E.

2133. *Fuel Calorimeter.* **C. R. Darling.** (Engineering, 73. p. 801, June 20, 1902.)—This is put forward as an improvement on Lewis Thompson's calorimeter, whilst providing an accurate apparatus less expensive than Mahler's. It has the advantages of electric ignition, of ingenious distribution of the resultant gases so that they are detained in contact with the water, and of rendering the combustion visible if desired, whilst giving constant results within 1 to 2 per cent. of error. The illustrations which accompany the article give a clear idea of the construction of the apparatus. [See also Abstract No. 542 (1902).] F. J. R.

GAS AND OIL ENGINES.

2134. *Ignition for Gas Engines.* **H. Mensforth.** (Mech. Eng. 9. pp. 621–625, May 10, 1902. Paper read before the Sheffield Society of Engineers and Metallurgists, April 28, 1902.)—With mechanically uncontrolled tube ignition, the point of ignition depends: (1) on the compression, (2) the speed of the engine, (3) the length and diameter of the tube, and (4) the temperature and distance of the incandescent portion from the combustion chamber. Up to 10 h.p. this system gives fairly satisfactory results. Its drawbacks are: (i.) its liability to pre-ignition when starting the engine; (ii.) when renewing a tube the new one may not be exactly the same as the one removed; and (iii.) the Bunsen burner cannot be relied upon to always heat the tube in the same position. The chief desiderata are: (1) that the risk of pre-ignition shall be a minimum; (2) long life for the tube and easy renewal; (3) a certain amount of adjustment, when running, of the time of ignition; (4) protection from damage in the case of a tube bursting; (5) the heated portion of the tube must be near enough to the combustion chamber to insure the prompt propagation of the flame into the charge; (6) if the ignition is controlled by a valve this should open rapidly as fully as possible; (7) the ignition port should be near to the opening for incoming charges in order to insure a circulation through it; (8) the Bunsen burner must heat the tube to a bright red and the gas supplying it must not be influenced by the suction of the piston on the gas mains.

Blast-furnace gas is often so poor that it will not burn under steam boilers. As it is expelled from the furnace it has a sensible temperature, giving in thermal units 5·7 B.Th.U. and a calorific value of 54 B.Th.U. per cubic ft. When cooled it has a 100 B.T.U., and when compressed to 7 or 8 atmospheres its thermal value is 430 B.T.U. per cubic ft. For this poor gas special ignition arrangements are essential, requiring (1) an exceedingly high temperature, (2) the area of (igniting) incandescence to be adequate and well sustained. Mixed gas and air under pressure enable any desired heat on the ignition tube to be got for the ignition with satisfactory results. Faulty

ignition is not always due to the ignition gear proper, one cause of late ignition is the presence of water in the cylinder. An examination of the exhaust-valve head will show the presence of water, as in such a case it will be coated with red oxide instead of being quite black. Oatmeal thrown in the tank supplying the jacket will cure some cases of leaking in the cylinder. Pre-ignition is often caused by some deposit in the cylinder becoming heated by the working of the cylinder. This is usually traceable to either tar in the gas, carbonisation of the lubricating oil, or foreign matter in the air inlet pipe, and this, getting hot, will cause pre-ignition. M. O'G.

2135. *Gas-Engine Temperatures.* **H. E. Wimperis.** (Engineering, 73. pp. 833–834, June 27, 1902.)—The author quotes F. W. Burstall's researches on gas engines and J. E. Petavel's on the emissivity of platinum at high temperatures and in gases at high pressures [see Abstract No 305 (1902)] and thinks that a variation of specific heat with temperature would explain the apparent gain of heat by the charge after the instant of highest temperature, which is usually attributed to a continuance of the combustion after that point. H. R. C.

2136. *Gas-Engine Exhaust Calorimeter.* **A. Staus.** (Zeitschr. Vereines Deutsch. Ing. 46. pp. 649–650, May 3, 1902.)—The author describes in this article the constructional details of the calorimeter devised by him, and used for measuring the heat, or its energy equivalent, left in the exhaust gas of gas motors. The author made an experiment with an old 4-h.p. gas engine (Otto type), and shows that very accurate results can be obtained. Means are provided of measuring the temperature of the exhaust gas when entering and leaving the calorimeter, and also the temperatures at entrance and exit of a stream of water which is sprayed into the calorimeter. The heat is determined by measuring the water and the rise of temperature. The gas is mixed thoroughly with the water before leaving the calorimeter. The amount of gas used by the motor during the experiment being measured, its heating value determined, and measuring also the amount of water flowing through the cylinder jacket, and the difference of temperatures in entering and leaving the jacket, the balance of heat left in the exhaust gas can easily be determined. Numerical results are given. L. G.

2137. *Aster Motors.* **L. Fournier.** (Locomotion Automobile, 9. pp. 374–377, June 12, 1902.)—The mechanical features of the water-cooled types of Aster petrol motors are described and illustrated. They are of the standard four-cycle type with vertical cylinders, automatic inlet and mechanically operated exhaust valves and fitted with high-tension electric ignition. The cylinder heads and bodies form separate castings, special attention having been given to the water-cooling of the cylinder head. In the electric ignition a positive cam action is employed for making and breaking the circuit to the induction-coil. C. R. D'E.

AUTOMOBILISM.[1]

2138. *Tests of Motor Cars.* (Automobile Club Journal, 4. pp. 15, 92, and 94, Aug. 28, and pp. 222–227, Oct. 9, 1902; Supplement.)—The results of the Automobile Clubs Reliability Trials are indicated by the number of marks given in the following table :—

[1] Electric Automobiles are described in the Section dealing with Electric Traction.

General Description.	Price.	1. Reliability. Maximum marks, 300 per day, for 6 days.	2. Hill Climbing.		3. Condition. Maximum marks, 500.	4. Steering. Maximum marks, 250.	5. Brakes. Maximum marks, 250.	6. Horse-power and Weight. Marks.	GRAND TOTAL.	Speed on Hills. Miles per hour.	
		Total.	River Hill.	Westerham Hill.						River.	Westerham.
3-*h.p. chain-driven Humber Bicycle*	£ 60	1795	418	—	430	250	250	125	**3268**	21·1	—
2-h.p. chain-driven Humber Bicycle	50	1727	—	—	325	200	250	—	**2502**	—	—
5-h.p. Century Tandem*	145	1790	137	—	500	250	125	68	**2870**	9·8	—
5-h.p. Baby Peugeot	150	1799	125	130	425	250	250	64	**3043**	9·3	7·3
1¾-h.p. Ormonde Bicycle	42	1724	—	—	225	250	250	—	**2449**	—	—
5½-*h.p. Locomobile*	200	1686	57	61	400	250	200	98	**2752**	15·1	12·2
5½-*h.p. Locomobile*	200	1736	47	42	450	250	150	80	**2755**	13·0	8·9
7-h.p. Star	300	1718	35	38	300	200	200	77	**2568**	5·3	4·3
5½-h.p. Locomobile	300	1382	39	35	350	250	150	73	**2279**	12·2	8·3
5½-h.p. Locomobile	300	1780	36	39	440	250	150	86	**2781**	13·5	10·9
4½-h.p. Renault	245	1624	55	—	485	250	250	49	**2713**	7·4	—
8-*h.p. M.M.C. Voiturette*	255	1751	52	60	500	250	250	116	**2979**	6·7	5·8
6-h.p. De Dion Bouton†	245	1735	84	87	440	250	200	110	**2906**	9·9	7·6
6-h.p. White Steam Car	300	1722	53	32	500	250	125	67	**2749**	11·3	5·1
6-h.p. White Steam Car*	300	1800	53	63	500	250	125	72	**2863**	10·2	9·2
10-h.p. Georges Richard	360	1481	45	—	—	250	—	115	—	8·3	—
9 h.p. James and Browne	400	1776	40	47	465	250	200	108	**2886**	7·3	6·4
12-h.p. Gladiator	400	1789	48	23	500	250	50	125	**2785**	9·2	4·6
10-h.p. Brooke	395	1774	25	32	480	250	250	88	**2899**	5·5	5·3
Light car fitted with Simm's 8-h.p. motor	375	1526	47	—	0	250	0	99	**1922**	7·2	—
10-h.p. Wolseley	390	1651	43	53	495	250	250	121	**2863**	—	—
7½-h.p. Wolseley	325	1785	28	—	500	250	200	100	**2863**	7·5	—
10-*h.p. Wolseley*	380	1795	49	61	500	250	200	127	**2982**	8·2	7·6
12-h.p. Belsize	385	1795	40	39	475	250	200	87	**2886**	6·8	5·7
9-h.p. New Orleans	315	1794	53	51	485	250	200	117	**2950**	8·8	7·0
8-h.p. De Dion Bouton*	328	1768	51	46	500	250	250	113	**2978**	8·3	6·5
8-h.p. Clement	365	1678	31	—	425	250	250	43	**2677**	6·1	—
10-h.p. Decauville	410	1770	25	31	440	240	250	119	**2875**	7·3	6·7
12-h.p. Gladiator	500	1643	40	42	495	250	50	149	**2669**	10·8	8·4
10-h.p. Ariel	450	1648	40	32	480	250	250	115	**2815**	8·7	6·5
12-h.p. Century	420	1452	66	59	240	150	0	110	**2077**	8·7	6·2
10-h.p. M.M.C.	450	1734	24	31	415	240	200	100	**2744**	6·0	5·8
7½-h.p. Germain*	450	1791	25	24	490	250	250	78	**2908**	6·1	4·5
6 h.p. Gardner-Serpollet	600	1713	38	33	495	250	150	204	**2883**	16·7	10·9
6-h.p. Gardner-Serpollet†	600	1761	44	32	500	250	150	196	**2933**	16·2	8·8
10-*h.p. Peugeot*	600	1793	56	42	475	250	250	173	**3039**	13·9	7·8
10-h.p. Brush	550	1634	25	5	465	250	200	108	**2687**	8·5	1·3
12-h.p. Humber	700	1794	26	30	470	250	200	111	**2881**	7·8	6·9
20-*h.p. Wolseley*	650	1800	34	41	495	250	200	193	**3013**	13·7	12·5
8-h.p. Wilson and Pilcher†	650	1787	26	10	500	250	250	101	**2924**	8·3	2·3
15-h.p. Germain	700	1797	36	40	465	250	200	167	**2955**	12·3	10·2
16-h.p. Clement	700	1574	29	35	130	250	250	197	**2468**	12·4	11·3
12-h.p. Daimler*	750	1786	28	30	475	250	250	165	**2984**	9·7	7·7
20-h.p. M.M.C.	800	1495	20	6	250	250	250	132	**2403**	10·7	2·5
20-h.p. Maudslay*	840	1797	26	27	500	250	200	115	**2918**	9·5	7·3
20-h.p. Pascal	860	1716	28	25	450	250	200	170	**2848**	15·3	10·5
20-*h.p. Pascal*	860	1780	22	28	475	250	250	132	**2937**	8·7	8·3
22-h.p. Daimler†	1150	1792	28	33	500	250	250	181	**3034**	13·0	11·6
22-h.p. Daimler	1150	1663	21	—	500	250	150	208	**2792**	13·7	—
15-*h.p. Panhard*	1150	1799	41	37	500	250	250	208	**3083**	16·5	11·3

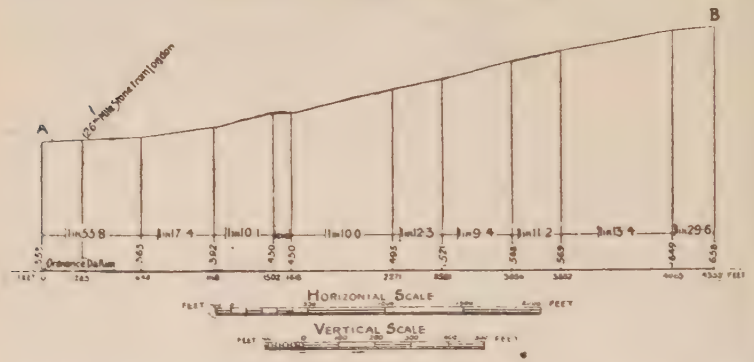
Horse-power and weight marks, Column 6, have been calculated by the following formula:—

$$\frac{\text{Horse-power as shown by performance} \times 100 \times \text{the number of passengers carried.}}{\text{Weight of car laden, less } 11\tfrac{1}{2} \text{ stone per passenger.}}$$

Italics mean gold medal. * Means silver medal. † Certificate for special piston rings.

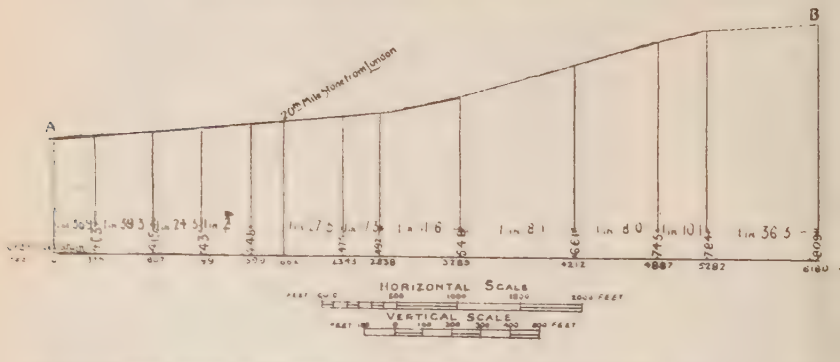
Rule 29 referred to in Column 1 reads :—There will be a maximum number of marks for reliability for each day's run, viz., 300, and one mark will be deducted for every minute during which the vehicle is at rest from the time of starting to the conclusion of the run, except for three compulsory stops

River Hill - Columns 2 and 8



per day for refreshments, and stops for traffic, tyre trouble, accidental detours, and lighting carriage lamps. Rule 32 referred to in Column 2 reads :—The marks awarded for the Hill Trials will be calculated as follows :—H.P. × 100,000 ÷ price in £ × 8 for every shillingsworth of fuel consumed.

Westerham - Betsoms Hill Columns 2 and 9



H.P. = horse-power as shown by performance, which for the purpose of this formula will be roughly calculated as follows :—Vertical height of hill in feet × weight of car and load in lbs. for every ton of total weight + 40 lbs. ÷ time in minutes 33,000. Appended are the profiles of River Hill and Westerham Betsoms Hill. M. O'G.

2139. *Stability of Automobiles on Curves.* **A. Petot.** (Comptes Rendus, 134. pp. 765–768, April 7, 1902.)—The paper contains a simple mathematical consideration, with a view to the guidance of experimental work, of side-slip and the tendency to upset when an automobile is turning, or following a curved route. When travelling in a circle there will be more tendency to side-slip on the part of the front wheels with increasing speed, and on the part of the rear wheels with diminishing speed. To prevent the latter effect

when braking, the brake must therefore be gradually applied. When the radius of the circle is decreasing—in other words, when the curvature of the path is increasing—the tendency of the front wheels to side-slip is accentuated, and that of the rear wheels when the curvature decreases, as, for example, in passing from a curve to the straight. The formulæ show clearly that, in order to avoid side-slip, the transition from one curve to another of different curvature must never be made abruptly, and the author believes that attempting to do this has been the true cause of several serious accidents which have been attributed to defects in the steering gear. A point which should be noted by designers and builders of motor cars is that the tendency to side-slip can be reduced by so distributing the weight of the car and its contents as to make the swing radius about the vertical through the centre of gravity as small as possible [that is by a concentration of the weight as near as possible to this line], and it is also of advantage that the weight should be symmetrically disposed with regard to it. G. W. DE T.

2140. *Renault Racing Cars.* **L. Fournier.** (Locomotion Automobile, 9. pp. 406–409, June 26, 1902.)—Describes the Renault voiturette of the "Circuit du Nord à l'alcol" type which is fitted with a 9-h.p. single-cylinder de Dion engine. The general arrangement of the mechanism is essentially similar to that of earlier types. [See Abstract No. 957 (1902).]
C. R. D'E.

2141. *"Rex" Motor Bicycle and Cars.* (Automotor Journal, 7. pp. 267–268, June 28, 1902.)—The Rex bicycle is a compact and strongly built machine carrying a 2-h.p. vertical engine mounted between the sides of the bottom bracket which is a malleable casting of special design. The engine has cylinder body and head cast in one piece and cooled by deep radiating ribs of square outline. The transmission to the rear wheel is by a V-section belt. Above the engine is mounted the surface carburettor and petrol tank, which contains a supply sufficient for 100 miles. The lubrication of the engine is effected by a hand pump.

The "Rex" cars are constructed in three sizes fitted with single-cylinder, vertical engines of from 6·5 to 9 h.p., and a larger vehicle of 12 h.p. has a double-cylinder engine. These engines are all water-cooled, with cylinders, bodies, and heads cast in one piece, and fitted with throttle governors. The smaller vehicles have change gears giving three speeds forward and one reverse, while the 12-h.p. car has four forward speeds. The former is transmitted through a friction clutch to the change gear and by bevel gearing to the live rear axle. C. R. D'E.

2142. *de Dietrich Lorry.* (Locomotion Automobile, 9. pp. 358–359, June 5, 1902.)—The latest type of internal combustion engine propelled lorry produced by this firm is described. It has a double cylinder horizontal engine mounted towards the front of a rectangular steel underframe and a transmission gear comprising a long belt from an extension of the crank-shaft to the first motion-shaft of the change-speed gear, and independent chains from the extremities of the second motion-shaft to the rear road wheels. The change gear gives four speeds forward and one reverse by means of sliding spur wheels. The engine may be run on either petrol or alcohol fuel. A cab enclosing the driver's seat occupies the front end of the underframe, and behind this is the body of the waggon. C. R. D'E.

2143. *Meredith Petrol Car.* (Automotor Journal, 7. pp. 224–225, June 14, 1902.)—In this vehicle the engine is horizontal and mounted towards the front of the underframe. It has two cylinders, 4·5 in. bore × 5 in. stroke mounted nearly opposite one another and bolted to the crank-enclosing chamber. The cylinders are water-cooled and 10 b.h.p. is developed at 700 r.p.m. The crank-shaft lies transversely to the underframe, and at its inner end outside the crank chamber is mounted the flywheel and friction clutch, from which the power is delivered to the first motion-shaft of the change-speed gear, this shaft being in line with the crank-shaft. Four sliding bevel wheels are mounted on the first motion-shaft, and these may be engaged with three bevel wheel rings on a disc keyed to a longitudinal shaft, from which the power is delivered to the live rear axle. The bevel change gear gives three speeds forward and one reverse. C. R. D'E.

2144. *Cronan Light Petrol Car.* (France Automobile, 7. p. 381, June 14, 1902.)—This car is fitted with a double-cylinder, horizontal engine, and a change-speed gear giving five changes forward and one reverse by wheels always in mesh; the final transmission is by bevel gearing to the live rear axle. A special feature is the timing gear for the electric ignition which is automatically advanced or retarded according to the speed of the engine. The throttle valve regulating the power of the engine is controlled by a rotational movement of the change-gear operating lever which is mounted on the steering pillar. C. R. D'E.

2145. *Chauveau Petrol Carriage.* (France Automobile, 7. pp. 394–395, June 21, 1902.)—The paper describes a type of car vehicle in which the power is transmitted to either of the rear road wheels independently, the one wheel having a higher ratio of gearing relative to the engine than the other. In this manner two changes of speed may be obtained and the differential gear suppressed. C. R. D'E.

2146. *Humber Petrol Cars.* (Automotor Journal, 7. pp. 213–218, June 14, and pp. 242–246, June 21, 1902.)—This is a detailed illustrated description of these vehicles. They are fitted with either a two-cylinder 8-h.p., or four-cylinder 12-h.p. engine, the general features of both types being almost identical. The underframe is constructed of steel tubing, and is sprung on semi-elliptic plate springs from front and back axles. The engine is mounted towards the front of the frame and covered by a bonnet. The power is transmitted through a cone friction clutch to the change-speed gear, which is of the sliding spur wheel type, and thence by a jointed tail-shaft and bevel gearing to the live rear axle. In the 12-h.p. engine the cylinders are of 3·5 in. bore and 4 in. stroke, and the normal speed is 900 r.p.m. The cylinders are water-cooled and fitted with both tube and electric ignition. Governing is effected by preventing the lifting of the exhaust valves. The carburettor is of the float-feed spraying type. In the friction clutch between engine and change gear a special feature is the placing of the springs so as to avoid end thrust. To allow for flexure in the frame a coupling is introduced between the clutch and the first motion-shaft of the change gear. The steering is controlled by a hand wheel, and three levers are provided for change speed, reverse, and driving-wheel brakes respectively. The clutch and a counter-shaft brake are operated by pedals. C. R. D'E.

2147. *Bertrand Petrol Car.* (France Automobile, 7. pp. 359–362, June 7, 1902.)—This is a simple, light, petrol car in which the engine is mounted

towards the front of the underframe with crank-shaft placed transversely and a long belt employed to transmit the power to a two-speed change gear mounted behind and carried from the live rear axle. When not driving, the belt runs on a loose pulley between two fixed pulleys, which correspond to two ratios of spur gearing between a counter-shaft and the axle. The reverse is obtained by a sun and planet motion within the loose belt pulley, this gear being brought into action by means of a pedal-controlled band brake which holds the planet pinions. C. R. D E.

2148. *Wolseley Petrol Cars.* (Automotor Journal, 7. pp. 192–194, June 7, 1902.)—Describes some further details of the transmission and steering gear on these vehicles. The countershaft and rear road wheel brakes are also illustrated and described. [See also Abstract No. 1782 (1902).] C. R. D'E.

2149. *Marlin Pneumatic Tyre.* (Automotor Journal, 7. pp. 268–269, June 28, 1902.)—This is a single-tube pneumatic tyre, but with accessible interior. In section the tyre is like an ordinary pneumatic, but with sides turned down and without beading. The extended walls butt up against the faces of the wood felloe of the road wheel, and are clamped thereto between metal side discs. By detaching one of these metal rings the interior of the tyre is readily accessible. C. R. D'E.

REFERENCES.

2150. *Vertical Compound Engine.* (Engineer, 93. pp. 456–458, May 9, 1902.)—This is a description of a 1,000-b.h.p. engine for the electric supply of Cape Town, built by Ferranti's, of Manchester. [See also Abstract No. 148 (1902).] H. R. C.

2151. *Determination of Stresses in the Upright Pillars of Vertical Steam Engines.* **G. Schwarz.** (Zeitschr. Vereines Deutsch. Ing. 46. pp. 724–729, May 17, 1902.)—The paper contains a mathematical and graphical treatment of frame stresses arising from the bending moments set up by the forces producing rotation. An elementary case is first considered and then developed. Engines of the Willans type whose pistons are only subject to a unidirectional pressure are included in the paper. R. C. R.

2152. *Metallic Packings.* **C. G. Robbins.** (Power, N.Y. 22. pp. 15–24, April, 1902.)—Descriptions are given of the principal packings now in use in the United States. G. W. DE T.

2153. *Steam-Engine Packing.* **A. McSwiney.** (Mech. Eng. 9. pp. 739–744, May 31, 1902. Abstract of paper read before the Birmingham Association of Mechanical Engineers.)—A description is given of various forms of metallic packings and stuffing-boxes. H. R. C.

2154. *Bunsen Air Injector Burners.* **J. S. V. Bickford.** (Horseless Age, 9. pp. 635–637, May 28, 1902.)—In this article the author describes a number of experiments he has made and the apparatus used in them. C. C.

2155. *Progress in Aëronautics.* **G. Espitallier.** (Génie Civil, 40. pp. 289–294, March 1; 309–313, March 8; and pp. 229–333, March 15, 1902.)—The first of these papers deals with the Santos-Dumont balloon (see Abstract No. 2457 (1901)], while in the second the author discusses the physical problems of the equilibrium of an elongated balloon, the dynamics of its motion through the air, the determination of the requisite motive power, and direct and indirect methods of measuring the velocity. G. W. DE T.

GENERAL ELECTRICAL ENGINEERING.

2156. *Accumulator Tests.* **M. U. Schoop.** (Centralblatt Accumulatoren, 3. pp. 93–96, April 15, and pp. 109–111, May 1, 1902.)—The researches described in these articles are in continuation of the author's investigations into the nature of the changes of discharge e.m.f. and p.d. [See Abstract No. 1348 (1900).] A number of curves are given showing the variations under different conditions of treatment, and from these it is deduced that their character is determined by (*a*) the rate of the previous recharge; (*b*) the length of time that elapses between the recharge and discharge; (*c*) the strength and temperature of the electrolyte; (*d*) the rate of discharge. Another series of curves shows the effects, upon positive and negative separately, of altering the thickness of the electrodes; and the diffusion phenomena from which they arise are discussed at considerable length.

E. J. W.

2157. *Influence of Temperature on Capacity of Accumulators.* **W. Hibbert.** (Elect. Rev. 50. pp. 883–884, May 30, 1902.)—The author discusses the results obtained by Dr. Gladstone and himself in 1892, and also more recent experiments of Schoop, Heim, and Liagre. [See Abstracts Nos. 2251 and 2465 (1901), and 393 (1902).] Heim finds the increase in capacity to equal 3 per cent. for each rise of 1° C., and Leagre shows that the percentage increase depends on the discharge rate. Heim gives the following figures for five large cells, working at a three-hours' rate—

		Ampere-hours.		
Temp.	Amperes.	Charge.	Discharge.	Efficiency.
12°	140	437	386	0·88
44·9	140	896	735	0·82

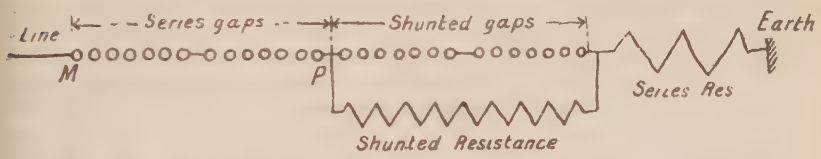
showing an increased capacity of 100 per cent.

All the results obtained may be explained as due to the increased diffusion of the acid in the pores of the active material. At low temperatures, the diffusion rate is too small to keep up the strength of the acid when from ½ to ⅓ of the active material has been changed to sulphate; at higher temperatures, the increased rate of diffusion keeps up the strength of the acid in the pores until much more sulphate has been formed. Heim recommends that accumulator rooms should be warmed in order to increase the capacity; the author dissents from this, owing to the increased local action on the positive plate, and the direct sulphating of the negative at the higher temperatures. Dr. Gladstone and the author pointed out this disadvantage in 1892, but also showed that the increased local action on both plates might be counteracted by a reduction in strength of the acid (Journ. Inst. Elect. Engrs., 1892, p. 31).

W. C. B.

2158. *Use of Shunt and Series Resistances in Lightning Arresters.* **P. H. Thomas.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 663–676, May, 1902.)—The "multi-gap" lightning arrester for alternating-current circuits consists of a number of small air-gaps, the terminal of the last air-gap being connected to earth through a resistance. Such a series resistance is found necessary for

the purpose of preventing the large rush of current which would otherwise follow discharges, causing a dimming of the lamps and throwing synchronous apparatus out of step. The use of such a series resistance of relatively high value in the path of the discharge is evidently in general an objectionable feature in the arrester. The value of the resistance may be reduced by the use of another resistance, which is arranged as a *shunt* across a number of the air-gaps. The arrangement is shown in the accompanying sketch. It is evident that when the arrester is not in action, the point P is at the potential of the earth ; hence the voltage on the line necessary to cause the arrester to discharge is that required to break down the series gaps alone. When this



happens the points M and P are momentarily reduced to practically the same potential, and the impulsive rise of potential at P next breaks down the shunted gaps. A current from the generator then follows the discharge, establishing arcs between the gaps. If, however, the arrangement is properly designed, the shunt resistance will take the bulk of the current flowing from P to earth, and the arcs in the shunted gaps will die out. The current now has to pass through the two resistances in series, and this reduces it so much that the arcs across the series gaps are entirely suppressed. The author discusses in detail the various points to be considered in designing an arrester of this type, and gives an account of the experimental investigations which he has carried out on this subject. A. H.

2159. *Construction of High-Tension Central Station Switchgears.* **H. W. Clothier.** (Inst. Elect. Engin., Journ. 31. pp. 1247–1264 ; Discussion, pp. 1264–1272, June, 1902.)—The paper deals with the construction of station switchgears as applied to the control of alternating currents. Various types of gear are described, being sectionised under two headings (*a*) gears with backs ; (*b*) gears without backs ; these being subdivided into boards of the (1) flat, multi-frame, cubicle, basement, and keyboard types ; (2) wall surface, hinged panel, pillar, and cellular types. The advantages of the different types are entered into, and the trend of the paper leads up to the most modern examples of switch-gears as recently installed in this and other countries. The author then compares the designs of British and German gears, drawing attention to the amount of space occupied by the latter, this being almost three times that taken up by the former. The bus-bar arrangements are fully discussed, and every feasible method of operation is described, attention being drawn to the departure from the simplicity of the older boards in the designs adopted for polyphase working. When arrangements were made for the supply of traction and lighting circuits from one station, it was possible that separate high-tension bus-bars were not required, in which case considerable economy would be effected, not only in the first cost of the gear, but also in the running of the station. Switches of the oil-break type are considered to be superior to those breaking in air, in that with the former the arc is suitably extinguished and rises of potential are kept down, whereas oscillations, likely to produce serious results, are set up when flare-switches are employed. If there were many underground cables on the

system, it became necessary to adopt feeder-charging gear to gradually raise or lower the pressure on any cable. The simplest and best method of connecting wattmeters in circuit was to place them between the generator and feeder panels, where they would register the entire output of the plant. The paper concludes with the expression of a belief that the tendency towards standardisation would produce a much simpler type and arrangement of gear than the designs at present in vogue. W. E. W.

2160. *The Lighting and Driving of Textile Mills by Electricity.* **M. Osborne.** (Inst. Elect. Engin., Journ. 31. pp. 1273–1280; Discussion, pp. 1280–1282, June, 1902. Paper read before the Dublin section, May 29, 1902.)—The author recommends the use of enclosed arc lamps for lighting textile mills, and quotes numerous cases in America where both alternating and direct current enclosed arcs have been successfully used for this purpose. He states that an enclosed arc taking 480 watts, fixed at a suitable height, will light an area of 1,100 sq. ft., if the materials are of a light colour; with materials of dark shades the area is reduced to 600 sq. ft. Incandescent lamps absorbing the same power would only illuminate half the same areas. The discussion, however, showed some divergence of opinion on this point. Some speakers considered that arc lamps were essentially unsuitable for textile operations, and very different estimates were given as to the precise amount of light required. As for the question of electrical driving, the author gave a general description of a large number of cotton mills abroad which were so driven, but instances were not to be found in England. In the case of a new mill, the author considers that it is evidently an advantage to adopt electrical machinery, and quotes the case of a mill of about 100,000 spindles, for which two sets of plans and estimates were prepared. One embodied electrical transmission of power, and the other was to be mechanically driven. The estimates for the electrical scheme were found to be the cheaper, in that it was possible to reduce the cost of the building by 10 per cent., the cost of shafting by 61 per cent., and the cost of belting and ropes by 66 per cent. This saving more than compensated for the cost of the electrical plant.
W. H. S.

REFERENCES.

2161. **P. Bayol.** (Écl. Électr. 30. pp. 265–275, Feb. 22; and pp. 342–348, March 8, 1902.)—A mathematical study of geometrical and other problems presented in the design of submarine cables. M. O'G.

2162. *Central Station Resistance Coils.* **P. Gesing.** (Elektrotechn. Zeitschr. 23. pp. 293–294, April 3, 1902.)—The author considers the usual calculations necessary for the construction and dimensioning of resistance regulators, as used in central stations, much too complicated, and gives a special table, from which, knowing the voltage of the dynamo, which is considered a constant, the lamp voltage, the maximum and minimum current, and the degree of adjustment required, the required dimensions can be obtained approximately from this without much calculation. L. G.

2163. *Automatic Transformer Switches.* **Winkler.** (Zeitschr. Elektrotechn., Wien, 20. pp. 221–223, May 4, 1902.)—A discussion of the points required of an automatic transformer switch, with a brief review of the attempts which have hitherto been made to fulfil the requirements. The author concludes that no completely satisfactory apparatus of the kind has yet been produced. A. E. L.

GENERATORS, MOTORS, AND TRANSFORMERS.

2164. *Regulation of a Gas-Engine Dynamo.* **Lauriol.** (Soc. Int. Élect., Bull. 2. pp. 413–424, June, 1902.)—The plant experimented on consisted of two dynamos driven by the same gas engine which was governed on the reduced charge system. Each dynamo supplied current at 1,500 volts for a constant load of arcs, the one a Henriot series machine giving a much steadier supply than the other, a Gramme machine separately excited. Girard proposed rectifying the unsteadiness produced by cyclic speed variations in the circuit of the Gramme machine, by periodically inserting resistance in the exciting circuit. The first trials showed that the necessary variation in resistance had been estimated too low. After some trials, a satisfactory arrangement was arrived at, the variation in the supply being reduced from 10 per cent. to 3·5 per cent. The theoretical difficulties encountered and the influence of self-induction are discussed. The latter necessitated a lead in the motion operating the resistance. The method is not applicable to hit-and-miss governed engines and no mention is made of variable load. Hospitaliers' ondograph method was employed for measuring the variation in the current supplied to the arcs. R. C. R.

2165. *Commutator Design.* **A. Rothert.** (Elektrotechn. Zeitschr. 23. pp. 309–314, April 10, 1902.)—This paper contains a critical review of the various theories of commutation, with special reference to Parshall and Hobart's method of calculating the "reactance voltage" of a short-circuited coil, and the effect of mutual inductance in cases where several coils are simultaneously short-circuited by the brush. Following Parshall and Hobart's method, the author developes the following formula for the reactance voltage :—

$$\text{Reactance voltage} = \text{constant} \times \frac{(\text{no. of conductors})^2 . (\text{length of iron} + 0{\cdot}1\ \text{free length}) . (\text{current in each conductor}) . (\text{revs. per min.})}{\text{number of commutator segments}}$$

The "free length" in the above formula stands for the length of conductor outside the slot. The value of the constant may be taken as 208×10^{-9}, the lengths being assumed to be expressed in cms. This formula enables us to find the number of segments for a given assumed value of the reactance voltage. A. H.

2166. *Alternator with Commutator.* **M. Latour.** (Soc. Int. Élect., Bull. 2. pp. 383–401, May, 1902.)—The author gives a description of his self-exciting polyphase alternator [see Abstract No. 1235 (1902)], pointing out its relation to continuous-current machines on the one hand, and ordinary alternators on the other. He refers to Heyland's work [see Abstract No. 2475 (1901)] and states that his own construction is practically identical with Heyland's, and that the only difference between them consists in the use of short-circuiting resistances between the commutator segments by Heyland—an arrangement whose sole object is to suppress sparking when only a small number of commutator segments is employed. The author criticises this arrangement somewhat severely, and regards it as quite unnecessary. A. H.

2167. *New Method of Compounding Generators.* **F. G. Baum.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 511–523, May, 1902.)—As applied to an

alternator, the author's method of compounding is shown diagrammatically in Fig. 1, where G is the generator, the main current from which excites the poles PP' of the "compensator." This latter consists of a field magnet between whose poles is rotated a single coil of wire, one end of which is attached to a continuous ring, while the other is connected to two segments

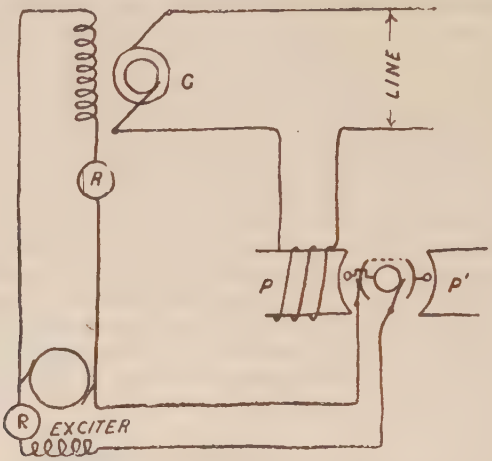


FIG. 1.

(each extending over 90°) of a split ring, these segments being in metallic connection with each other. The e.m.f. developed by the armature of the compensator is injected into the field circuit of the exciter. The compensator is driven synchronously with the generator by suitable gearing. The e.m.f. developed by it consists of a portion of an alternating wave of e.m.f., and

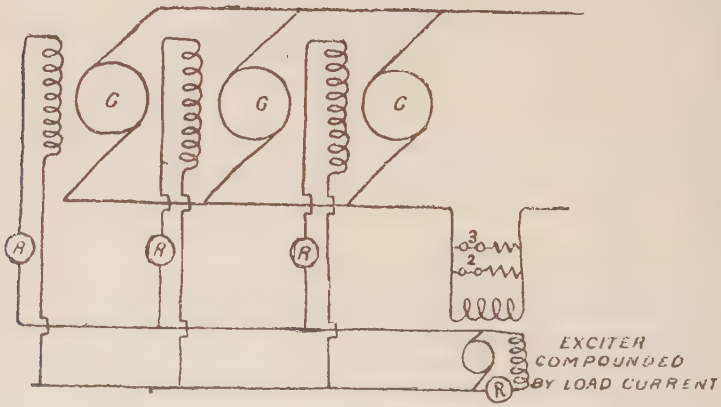


FIG. 2.

may itself be either alternating or uni-directional, depending on the phase of the current relatively to the position of the compensator armature. The phase of the current thus determines the amount of e.m.f. injected into the field circuit of the exciter. In practice, instead of connecting the exciter field and the compensator armature in series, the latter is allowed to excite the field of a small dynamo whose armature supplies current to a

special series coil on the exciter. A method of compounding continuous-current generators analogous to the one just described for alternators is shown in Fig. 2, where the G's represent the generator armatures, the R's rheostats in their field circuits, and 2 and 3 are shunts across the exciter series coil, by means of which the compounding may be varied to suit the number of generators running. The author states that these methods have given very good results in practice. A. H.

2168. *Determination of Alternator Characteristics.* **L. A. Herdt.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 723–751, May, 1902.)—The relations between the values of the e.m.f. current and induction fluxes of alternators under varying conditions of load and power-factor are discussed theoretically, and the conclusions arrived at are tested by careful and elaborate experiments on various types of machine. The reluctance of the path of the armature flux of an alternator is periodically changing, and it is shown that this fluctuation has a marked effect on its regulation and wave-form. E.m.f. current and induction waves are drawn for an inductor alternator on non-inductive, inductive, and condenser loads respectively. The great change in the shape of the wave which occurs in this type of machine is a drawback in practical work. The shape of the induction wave with quadrature current proves that the diminution of voltage on an inductive load is almost entirely due to the demagnetising effect of the armature current. Several indirect methods of determining alternator regulation are given. The method of predetermining the regulation from the short-circuit characteristic is shown to be inaccurate owing to the demagnetising effect of the quadrature current being much greater when the field excitation is weak and also because the power and inductance factors of the load are not the same as the power and inductance factors of the whole circuit. Blondel's "two reaction" method is given, and it is stated that it neglects armature self-induction. The author gives a new method which he calls the "two reactance" method. The armature, instead of being short-circuited, is operated at full load field excitation on a suitable variable reactance and the difference between the terminal voltage and the no load voltage is noted. This voltage drop divided by the current gives the value of the demagnetising component of the "synchronous reactance" or the combined effect of armature reactance and the stray field due to the cross magnetising effect of the armature current. The cross magnetising effect is equal to this demagnetising component multiplied by the ratio of the maximum to the minimum value of the armature reactance. It is shown that the various values of the armature reactance can easily be found by passing an alternating current of known frequency through the armature held fixed in various positions. The characteristics for various power-factors determined in this manner agree with the actual curves within the limits of experimental error. A. R.

2169. *Multiple-Speed Motor.* (Power, N.Y. 22. pp. 45–46, June, 1902.)—No rheostats of any description are used in this motor, which is manufactured by the Stow Manufacturing Company, of Binghamton, N.Y., the speed variation being obtained by varying the reluctance of the magnetic circuit. The machine illustrated is a 6-h.p. motor capable of running sparklessly at from 700 to 1,500 r.p.m. From a circular yoke project 4 pole-pieces of special construction, each consisting of an outer hollow cylindrical casing whose inner end is shaped to form the pole-shoe, and a solid piston capable of sliding inside the hollow casing. The outer end of the piston is provided

with a screwed shank which passes through a nut, the nut forming the boss of a bevel wheel. By means of a single hand-wheel and a suitable arrangement of bevel gearing the four pistons may be moved simultaneously through equal distances in a radial direction. An outward displacement of the pistons increases the reluctance of the magnetic circuit by increasing the length of air column between the inner end of the piston and the armature core. Sparkless running is said to be obtained by the great increase in the induction close to the polar tips. A. H.

2170. *Theory of Synchronous Motor.* **C. P. Steinmetz.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 547–567, May, 1902.)—After briefly sketching the theory of the synchronous motor, the author draws a series of curves connecting output with current, power-factor and efficiency, for a given excitation. These curves closely resemble similar curves for the induction motor, but while an induction motor has only one series of load curves a synchronous motor has an infinite number of them, each value of the exciting current corresponding to a different set of load curves. The load curves for one particular value of the exciting current show that the power-factor is practically unity over the whole range of load up to near the maximum output. The author next considers sudden changes of load and their effect in setting up surging or hunting; a formula is deduced for the frequency of the oscillations when these are small, and its application to a numerical example brings out the fact that the frequency of oscillation does not vary much with the load and the excitation; it slightly decreases with increase of load, and increases with increase of excitation. The concluding section of the paper deals with the effect of changes in the load due to changes of speed, and with anti-surging devices. A. H.

2171. *An 80,000-Volt Transformer.* (Elect. World and Engineer, 39. pp. 1067–1068, June 14, 1902.)—A 330-kw. transformer of this voltage is described, recently built by the General Electric Co. for the local lighting and power company in Butte, Mont., the distance of transmission being 60 miles. It is of the oil-insulated type, similar in design to the 500-kw. 60,000-volt transformers recently made by the same company. The method adopted for forcing the oil into the interstices of the windings is to exhaust all air with a vacuum pump (the transformer case and all joints, glands, &c., being made airtight for this purpose), heat the windings to expel all moisture, and then to allow the oil to flow in under atmospheric pressure. The spaces between the high voltage coil and the other parts are subdivided into separate ducts by diaphragms of solid insulation, so that any conducting particle which might chance to fall into the oil should do the least possible harm. The transformer was designed more with a view to absolute reliability than for high efficiency, which is given as 97·5 per cent. at 60 cycles. The regulation is stated to be 1 per cent., reactance 4 per cent., heating (by resistance) 30° C. Insulation tests made at 160,000 volts failed to develope any weakness; but during these tests it was found necessary to fix india-rubber discs on the terminal cables, as otherwise an arc formed between the ends of the cables and the transformer tank, even over a distance of 5 or 6 ft. the discs broke the continuity of the static discharge and prevented arcing. At the normal pressure of 80,000 volts there is no brush discharge whatever, and the discs are therefore not necessary in ordinary operation. Tests were made for dielectric hysteresis, but no losses due to this cause were observed. B. P. S.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

2172. *Earthing High Potential Systems.* **J. D. Nies.** (Elect. World and Engineer, 39. pp. 639–642, April 12, 1902.)—The author discusses mathematically the part played by static capacity when the zero point is earthed in monophase and polyphase systems. If the static capacity between the lines and earth was negligible, earthing would obviously introduce a source of danger. This, however, is very rarely the case, and in most cases occurring in practice this static capacity is a source of danger as great as, or greater than, that due to earthing. In such cases, earthing will usually not sensibly increase the danger arising from accidental contact with the lines, and will frequently diminish it to a considerable extent. As earthing, in most cases, conduces to reliability of operation, the conclusion is that it is usually advisable. G. W. DE T.

2173. *Steel Posts.* (Electricien, 23. pp. 326–328, May 24, 1902.)—These are made by Genissien, 32, rue de Greffselhe Levallois Perret (Seine), by bolting together two channel irons so as to give the appearance of a square post. Taper is obtained by sliding smaller irons within the larger ones and covering the join with a cast-iron moulding. The post is 80 per cent. cheaper than tubular posts, and 30 per cent. cheaper than trellis-work. It may be installed by a pile driver, is easily ornamented, and from its square shape and the slot between the two channels it is adapted to support an arm without even being drilled with holes. M. O'G.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

2174. *The Joliet Water-power Plant.* (Eng. Record, 45. pp. 362–365, April 19, 1902.)—This plant, deriving power from the Chicago drainage canal, presents some interesting features on account of the low head utilised, and the large amount of water available. The plant will have ultimately a capacity of 7,000 h.p. at the switchboard. The high-water head is 9 ft., and the head at all stages between high and low water somewhere between 9 and 14 ft. The low-water flow contemplated is 420,000 cubic ft. per minute under 14 ft. head. To give the same power under 9 ft. head will require 653,000 cubic ft. of water per minute. The high-water flow, it is calculated, amounts to 1,500,000 cubic ft. of water per minute. The highest efficiency of the wheels was desirable at low water and high head. The power-house is 45 ft. wide and 875 ft. long. The ultimate installation of 40 turbines is provided for. A flow into the Illinois and Michigan canal of 30,000 cubic ft. of water, at a fall of 14 ft., drives one 375-kw. generator, from two 66-in. "New Success" turbines. The bay for each turbine of this pair is arranged to discharge the water either into the basin at the mouth of the tunnel or into the tailrace carrying the water from the rest of the wheels. The head under which the wheels operate is substantially constant. Two 750-kw. units, each driven by three 66-in. McCormick turbines, have been installed. There are also two 75-kw. 125-volt exciters with their wheels, each having sufficient capacity for the whole plant. The masonry and the floors of the building are

of concrete. The superstructure is of hollow tile walls and steel framework. When the head falls as low as 9 ft., six 66-in. wheels are needed to drive one 750-kw. generator. Each unit therefore has six wheels, three of which can, by means of clutch couplings, be coupled to the generator at will. The auxiliary turbines are "New Success" turbines of the wicket-gate type. The exciter of the 375-kw. generator is driven by a 48-in. wheel. The turbines are of the vertical type, and are connected by means of bevel gearing to the horizontal shaft, to which the alternator shaft is coupled. The cone wheels have but 3·5 in. pitch, and have run satisfactorily. The scheme of regulation is believed to be entirely new. Lombard governors are used, and act on the cylinder gates only. The arrangement gives a rigid connection between governor and gates, and works well. When loaded to 600 kw., the instantaneous removal of 400 kw. caused a change of only 2 cycles in 60, with recovery in a second or two. The turbines are located at the bottom of the chamber, which is 9 ft. below the level of the top of the dam. The turbine floor level is normally 1 ft. above the tail at low level. The tailrace is 75 ft. wide. The alternators are of the revolving field type, containing 36 poles. They run at 200 r.p.m., and give three-phase current at 60 ∿ and 2,300 volts. For transmission purposes for street railway service the step-up transformers give 15,000 or 25,000 volts, according as the connections are made in the delta or star fashion. There are four transformers of 200 kw. each, air-cooled by centrifugal fans. The high-tension lines are controlled by double-throw oil-break switches. L. G.

2175. *The New Shoreditch Electricity Works.* (Elect. Engin. 29. pp. 870–877, June 20, 1902.)—*System.*—High-pressure continuous current, generated at about 1,100 volts; distribution to consumer on two-wire system. The boiler-room contains four water-tube boilers of the Babcock and Wilcox marine type, each having a heating surface of 2,720 sq. ft. The grate area of three is 73½ sq. ft., the fourth 68 sq. ft. The four boilers combined produce about 50,000 lbs. of steam per hour. The feed-water is heated by economisers, each containing 350 sq. ft. of heating surface, fitted to each boiler. Coal is stored in overhead coal store of 750 tons capacity, while an automatic railway is provided for handling and trimming, and is fired by three boilers hand fed, the fourth fitted with a double 4-ft. Babcock and Wilcox chain stoker. The engine-room contains two vertical slow-speed Corliss compound engines, running at 90 r.p.m., and capable of developing from 1,300 i.h.p. to 1,400 i.h.p. Diameter of high-pressure cylinder, 24½ in.; of the low pressure, 53 in.; stroke, 42 in. Each engine provided with a surface condenser having a cooling surface of 2,700 sq. ft. Each engine drives direct-coupled multipolar dynamo of the Westinghouse type, the rated load of each being 730 amperes and 1,100 volts. They are designed to carry an overload of 50 per cent. for two hours. The average price obtained for the year 1900–1 was 3·08d. per unit for lighting. C. E. A.

2176. *Camps Bay, Cape Town, and Sea Point Tramways.* (Tram. Rly World, 11. pp. 134–142, March, 1902.)—The main route is about 7 miles long, with two short branches. It is extremely tortuous and very heavily graded, the average grade over one length of 1¼ miles being slightly steeper than 1 in 12, with grades of 1 in 9 for short distances. In addition to the new roadway which had to be constructed, more than 75 per cent. of the existing roads had to be widened and graded, involving much earthwork and blasting. Girder rails weighing 90 lbs. per yard, laid in strips of concrete 6 in. deep and

18 in. wide, are used for the track. The gauge is 4 ft. 8½ in., to correspond with that of the Cape Town tramways. Karri wood paving has been laid for a width of 1 ft. 10 in. on each side of the track, with a 9-in. toothing course along the inner side of each rail. Neptune rail bonds are used, and 3 ft. 8 in. cast-steel points, and 1 in 9 crossings. The overhead trolley system is employed, the trolley line being supported on side-poles of mild steel. The generating station at Camps Bay, about the centre of the system, contains two direct-coupled 400-kw. units with cross compound, 720-b.h.p. engines fitted with Corliss automatic valve gear, running at 90 r.p.m, with a steam pressure of 150 lbs. There are two Admiralty type surface condensers adapted for use with sea-water, and with combined air and circulating pumps. There are two Babcock and Wilcox boilers, each capable of evaporating 12,000 lbs. of water per hour under normal conditions. The feed-water is heated by a Green's economiser. The car bodies are mounted on bogie-type trucks, with a 4-pole-type 25-b.h.p. motor on each axle, 100 b.h.p. per car (carrying 54 or 65 passengers) being considered necessary on account of the heavy grades. Each car is fitted with three brakes : a hand brake with a brake-block on each of the eight bogie wheels, an air brake acting in conjunction with the hand-brake, and an auxiliary slipper brake. In addition to these, it is also possible, by throwing over the reversing switch, to convert the motors into generators, thus enabling them to act as a powerful emergency brake. G. W. DE T.

2177. *The Paris-Arpajon Railway.* **G. Böeto.** (Génie Civil, 40. pp. 421–428, April 26, 1902.)—This light railway, 32 km. long, has hitherto been worked on a mixed system by steam and compressed air. These are now supplemented by an electrical system, which is worked by accumulators carried on locomotives between the Odéon and the boundary of Paris, and from this point to Antony, a distance of about 8 km., by the trolley method. Steam is also still used over the whole line, and compressed air for some of the trains inside Paris. The electric power-house is in the station which is used for generating the compressed air, and contains two 225-kw. dynamos coupled to Corliss engines, giving their output at 550 volts, and 120 r.p.m. An accumulator substation is placed at Bagneux, 3 km. from the power-house ; this contains 270 Tudor cells, giving about 100 kw. for three hours. The locomotives carrying accumulators weigh 17 tons ; the cells have a capacity of 110 ampere-hours, and are 250 in number. They take on an average fifteen minutes to charge. The article contains a large plate with drawings of the power-house. W. H. S.

2178. *Brockton and Plymouth Street Railway.* (Street Rly. Journ. 19. pp. 243–250, April, 1902.)—Three-phase transmission is employed, at 13,000 volts and 25 ∿ , to a 13-mile distant substation. The track is laid with 60-lb. T-rails (a girder rail is used in Plymouth), and chestnut and oak ties with gravel or sand ballast, and paving on steep grades. There are four horizontal return tubular boilers, each rated at 125 h.p., with heads and shell plates of open hearth steel. The steam pressure is 125 lbs. High-pressure steam pipes are of lap-welded charcoal iron, work of 2½ in. and over being flanged. The high-pressure steam and water pipes have adjustable supports on roller bearings at least every 6 feet, the low-pressure piping having fixed supports. Warren feed-pumps are used, and exhaust primary heaters. There are two Blake jet condensers of the cross-compound vertical air-pump type, which can be operated together if desired. There are at present 3 units. (1) A 300-kw. G.E. three-phase revolving-field 380-volt alternator with 28 poles,

direct-connected to a 450-h.p. cross-compound condensing engine. The speed is 107 r.p.m. with a guaranteed regulation of 2 per cent. from zero to full load, and a maximum angular variation of 0·18 of 1 per cent. at 50 per cent. overload. Multiported gridiron valves give full steam-chest pressure with short travel and little wear, and are actuated by a double-eccentric motion, allowing the widest possible range for adjustment, and a cut-off up to three-quarter stroke. This is found to give exceptional capacity for handling high-speeds and changeable loads. The speed can be varied while running, to the extent of about 10 r.p.m., by means of an electromotor connected through a sprocket chain to a screw which moves a weight along the governor trip-shaft. (2) A G.E. 300-kw. 8-pole 550-volt 105-r.p.m. direct-current railway generator direct-driven by a 450-h.p. Green-Wheelock horizontal cross-compound condensing engine. (3) A G.E. 200-kw. 550-volt direct-current railway generator, direct-connected to a 250-h.p. McIntosh and Seymour engine. Six 90-kw. 380–13,000-volt oil-cooled transformers are guaranteed, with overload capacity, to supply two 200-kw. overloaded rotaries at the substation. Each car weighs 13,000 lbs., and carries four G.E.-52 motors with K-12 controllers rated at 27-h.p. on the low basis of 75° C. temperature rise. The trucks are of the double-motor swing-bolster type, with an overall axle length of 6 ft. 2⅝ in., a length of 10 ft. 2½ in., and a wheel base of 4 ft. 4 in. Inside-hung Christensen air-brakes are used, and the motor-gear ratio is 4·78. The road is operated on the telephone despatching system. G. W. DE T.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

2179. *The Zossen Marienfelde Polyphase Railway Trials.* (Engineering, 73. pp. 547–548, April 25, 1902.)—In the trials hitherto made special attention was given to the following points: (1) Starting and braking at speeds up to 100 km. (62 miles); (2) running at uniform speeds up to 100 km.; (3) propulsion at uniform speeds up to 130 km. (81 miles); (4) propulsion by high-pressure currents at speeds above 130 km. The rails on this line weigh only 34·4 kg. per m. (67·5 lbs. per yd.), and rest partly on wooden and partly on iron sleepers. As expected, the defects in the track became manifest at high speeds. Up to 100 km. no concussions were noticed in the carriages, nor were distorsions observed. After 140 km. (87 miles) there was slight rolling, owing to the lightness of the permanent way. The three-axled bogies were quite satisfactory, giving noiseless motion without any jolting at the rail joints. The experiments would tend to show that rails weighing 42 kg. per m. (84·5 lbs. per yd.) would be quite heavy enough for speeds up 160 km. (100 miles). The quiet motion was doubtless largely due to the complete balancing of the car. There was very little sparking, even at the highest speeds, at the contact bows, which exerted a pressure of 4–6 kg. (9–13 lbs.) against the trolley wires, and, when observed, it could be traced to slight defects in details. Lateral oscillations in the car were only observed at speeds below 60 miles. The heating of the transformers on the car did not exceed 35° C. At the lower speeds employed in the earlier trials, the trolley-line pressures varied from 6,000 to 8,000 volts, with a periodicity of 25–30. For the higher speeds the pressure was raised to 10,000 volts with a periodicity of 36, and temporarily to 13,500 volts with a periodicity of 48. At the highest speeds, between 99 and 100 miles an hour, the rails began to

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

yield, both horizontally and vertically, so that the tests had to be interrupted, pending the strengthening of the permanent way. With regard to braking, the conclusions arrived at were that further and more efficient means should be devised. Braking by current reversal is not to be recommended, as it endangers the motors. The power consumption, depending on the speed and the starting acceleration, varied between 400 kw. and 700 kw. With a power consumption of 184 kw. a uniform speed of 90 km. (56 miles) could be maintained, and 140 km. (87 miles) with 520 kw.; so that about 1,100 h.p. would be required for a speed of 200 km. (125 miles). The air-resistance experiments showed that the rise in air pressure did not extend beyond a distance of 3·3 m. in front of the car. The rounding of the sides and roof was found to be a very important feature. There was practically no increase of pressure on the rear portion of the car, nor was any noteworthy suction effect observed in its wake. [See also Abstract No. 598 (1902).] G. W. DE T.

2180. *High-Speed Electric Railways.* **G. W. Meyer.** (Zeitschr. Elektrotechn., Wien, 20. pp. 169–174, April 6, 1902.)—The author commences by discussing certain formulæ for the determination of the horse-power required to drive a train at certain speeds, taking into account the air resistance. He also refers to the work already done by Reichel, Kapp, and others on this subject. He then proceeds to consider the system most suitable for main lines, and thinks that this must obviously be the polyphase system without any admixture of direct current or rotary convertors. Two methods are therefore possible, viz., system A, in which the high-tension current is transformed in substations, placed at intervals along the line, alternate current being then supplied at lower pressure to the locomotives; and system B, in which the high-tension current is transformed by transformers carried by the trains themselves. The trains are supposed to consist of single cars, holding 90 persons; on system A, the loaded cars would weigh 110 tons, and on system B, 145 tons. The speed is taken as being 180 km. per hour with a maximum speed of 200 km. By the application of the formulæ, a train on system A is found to require 1,800 h.p., or 1,420 kw., allowing for losses in the motors; on system B, it would require 2,000 kw., allowing for losses in motors and transformers. The former therefore requires four 500-h.p. motors, and the latter four 600-h.p. A further allowance must be made in favour of system A in consequence of the fact that much higher transmission pressures are possible in this case; current transmitted at the highest pressures cannot conveniently be dealt with on the train itself, whereas a pressure of 55,000 volts presents no difficulties in substations. The author then considers the case of running half-hourly trains between New York and Chicago, and calculates that the amount of power required under the two systems would be in the proportion of 10 to 13. In consequence of the higher pressures used in system A, one or at the most two central stations should be possible; in the case of the New York and Chicago line, the whole could be supplied from Niagara, and each substation would supply 40 km. of the line at 6,000 volts. Supposing in the case of B that 20,000 volts was a possible pressure, the Chicago and New York line would require ten central stations, and each of these would supply a length of about 160 km. of the line. W. H. S.

2181. *Competition of Steam and Electric Railways.* **C. H. Davis.** (Street Rly. Journ. 19. pp. 310–314, April, 1902. Paper read before the Canadian Society of Civil Engineers.)—The paper discusses in detail, with numerous

curves and tables, the financial effects of the competition of electric street railways, on various steam railroads in the United States, during the period from 1889 to 1898. The conclusion arrived at is that where steam railroads have been seriously affected by the competition it is almost invariably due to their routes being ill-adapted for local traffic, and that the general effect of the development of the electric street railways is to largely develope local passenger traffic, and, by good management on the part of the steam railways, may be made to act as feeders to them, and therefore increase, instead of diminishing their profits. G. W. DE T.

2182. *Electric Railways.* **L. Gerard.** (Soc. Belge Élect., Bull. 19. pp. 183–281, April, 1902.)—This is a critical discussion of the various systems of electric traction, with illustrations drawn from numerous important systems in use in Europe and America. The relative advantages of electricity and steam are specially discussed, the preference being given to the former, mainly on account of the high efficiency attainable and the reduction of dead weight to a minimum. Accumulator attraction is at a disadvantage in both these points, and is only to be contemplated under quite special conditions. G. W. DE T.

2183. *The Diallo Surface-Contact System.* **C. H. Julius.** (Assoc. Ing. Él. Liège, Bull. 2. pp. 63–126, Jan., 1902.)—This is a very complete treatise on the system, with a discussion of its development and working in Paris, a comparison of its capital and maintenance costs with those of the trolley system, and a full consideration of the various imperfections which have been discovered in practice and the methods of eliminating them. The author's conclusion is that the system is one of great value for use in places where trolley lines are excluded, and that the difficulties which have hitherto arisen are all of a kind that can be overcome in the light of the experience which has been obtained in the use of the system in Paris. The paper is illustrated by numerous sectional drawings. [See also Abstracts Nos. 1992 (1899) and 396 (1900).] G. W. DE T.

2184. *The Transition Spiral.* **W. M. Torrance.** (West. Soc. Engin., Journ. 7. pp. 145–163; Discussion, pp. 163–216, April, 1902.)—The author contends that in order to obtain the best possible riding quality for fast trains resort should be had to the use of transition spirals. The correct method of obtaining super-elevation at the end of a curve is to insert between the tangent and the circular curve a transition spiral in which the curvature increases from zero at its tangent end directly with the distance from the end to the curvature of the regular circular curve at its other end. The centrifugal force which renders super-elevation necessary is directly proportional to the curvature at any point. If super-elevation is introduced into the line on the spiral, in exact proportion to the curvature in it, every condition for an easy riding is satisfied. The author does not agree that financially, and from an engineering standpoint, it is difficult to maintain a spiralled curve, as, properly constructed, it will practically maintain itself, whereas, if there is no spiral the line is certain to require constant attention on the part of the trackmen. The author supports this by contending that there are very few main-line curves which the permanent-way men have not found necessary to "ease off" if the engineer has not come to their aid by giving them spirals. Other salient points of the paper are: (*a*) That it is always possible on an old track to add spirals to the curves by throwing them out so little as to be quite

inexpensive ; this will be especially true if the spirals are added while other work, such as extensive ballasting or doubling the line, is being done. (*b*) To see that after the spiralled centre line is staked out and the track is being made to conform to it, for line, the ends of the super-elevation run-off are made by the permanent-way men to conform exactly with the ends of the spiral, and that the change from zero at one end to the full super-elevation is obtained proportionately to the distance from the zero end. The discussion brought into prominence the fact that most practical engineers in charge of maintenance declared in favour of spiralling railway curves, although views antagonistic to the principle were freely expressed. The most important were that spirals do not help a moving train to run in a circular direction, as the motion is as much "on tangent" when it has reached a heavy curve direct from tangent as when supposed to be coddled into curvature by a spiral. Further, that lateral elevation is dependent on curvature and *speed*, and that the road most perfectly spiralled for one degree of speed is a bad misfit for all other speeds. The latter objection, however, applies to any curve having lateral elevation, whether spiralled or not. The paper describes various methods for spiralling curves on maintenance work, and is accompanied by useful diagrams and tables. C. E. A.

2185. *Electric Locomotive for Rack and Adhesion Railway.* **M. Gaze.** (Zeitschr. Vereines Deutsch. Ing. 46. pp. 600–605, April 26, 1902.)—The author describes a short line which has been constructed for the purposes of a sugar refinery on the Elbe, the steepest incline on which is one of 15 per cent. It is worked partly by adhesion and partly by the Abt rack. The article deals mainly with the mechanical construction of the locomotive and track, and specially notices such details as are connected with the passage from the rack-driven part of the line to the other portion. W. H. S.

2186. *Tractive Effort and Power of Tramway Motors.* **H. C. King.** (Tram. Rly. World, 11. pp. 383–386, June, 1902.)—This paper discusses the points to be taken into consideration in the selection of tramway motors. For suburban work high speeds, for city work high accelerations are required —higher in proportion to the density of the traffic. Acceleration should not be uniform, but small at first, say 0·5 ft./sec.2 increasing to as high a rate as possible ; the mean acceleration can thus reach a high value without discomfort to the passengers. Attention should be paid to the pairing of motors so that when coupled in series each may take its proper share of load without differing in speed from the other. A convenient way of making the pairing test is described. A diagram is given showing graphically (1) tractive effort as a function of weight of car and gradient ; (2) the same as a function of weight of car and acceleration; (3) b.h.p. as a function of tractive effort and speed, and by numerical examples the use of the diagram is explained. B. P. S.

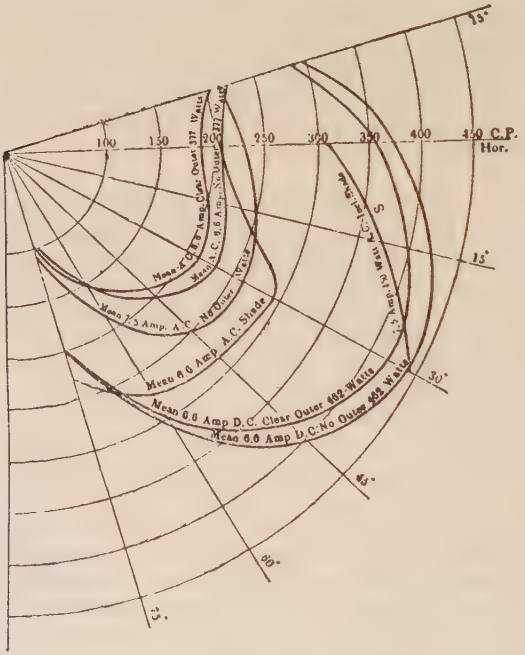
ELECTRIC LAMPS AND LIGHTING.

2187. *Photometric Tests of Arc Lamps.* (West. Electn. 30. p. 362, May 24, 1902. Abstract of report presented to the National Electric Light Association at Cincinnati, Ohio, May 21, 1902.)—This is the third report of the Committee. [See also Abstracts Nos. 2347 (1900) and 2044 (1901).] It deals mainly with enclosed arc lamps, and the results are summarised in the appended diagram. The lamps in all cases were run with opalescent inner globes ; but, as shown

on the diagram, some of the curves were taken with clear outer globes, some with no outer globe, and some with a street shade. The 7·5-ampere alternating-current lamps have a power-factor of 0·83, and take therefore about the same amount of power as the 6·6-ampere direct-current lamp. The power-factor of the 6·6-ampere alternate-current lamp was 0·88. The watts per mean hemispherical c.p. for the different types were as follows :—

D. C. 6·6-ampere op. inner, clear outer	1·31 watts per c.p.
A. C. 6·6-ampere op. inner, clear outer	1·92 watts per c.p.
A. C. 6·6-ampere op. inner, shade	1·48 watts per c.p.

Another diagram gives the light obtained by the expenditure of 450 watts in an arc lamp under varying conditions. The variations considered include

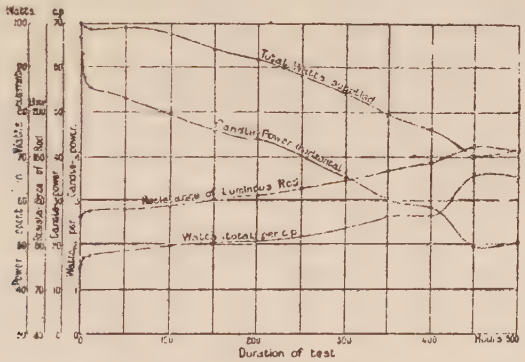


those due to direct- and alternating-current, open and enclosed arcs, current large or small, clear and opalescent globes, &c., the current in all cases being inversely proportional to the e.m.f. A further diagram gives the photometric value of an arc lamp plotted as a function of the height of the lamp. For the open arc with a height of 40 ft., the greatest mean illumination is obtained. With the enclosed arc the results are somewhat contradictory ; but the maximum mean illumination seems to be obtained with a height of between 25 and 30 ft. W. H. S.

2188. *Tests of the Nernst Lamp.* **R. P. Hulse.** (Inst. Elect. Engin., Journ. 31. pp. 1180–1196 ; Discussion, pp. 1196–1199, June, 1902. Paper read before the Birmingham Section, March 19, 1902.)—The following tests were carried out on *continuous* current, the lamps taking 0·9 ampere at 110 volts. All the candle-powers were measured in a horizontal direction with the filament vertical. The current was supplied with a battery of accumulators,

and the runs were perfectly continuous. When run at 110 volts on direct-current the average life of three filaments was found to be 473 hours, the c.p. falling from 66 to 20, and the watts per c.p. rising from 1·51 to 3·61. The c.p. falls about 6 per cent. in the first hour of running, but after that the rate of fall is much slower. The appended curves summarise the results of this test.

The cause of breakage in all cases was found to be the fracture of the platinum contact at the positive end of the filament. The author calculates that after 350 hours the lamp has reached the end of its economical life, and therefore its relatively short life is no disadvantage. A further test was made in which the lamps were overrun at a pressure of 116·5 volts. The efficiency at the start in this case was 1·32 watts per c.p., and after 200 hours it was 1·85 watts per c.p., the lamp breaking after 220 hours. The efficiencies were therefore only slightly better than in the preceding case, while the life was rather less than half its preceding amount. When run with constant current



of 0·89 ampere, the life was 372 hours, and the watts per c.p. in this test rose from 1·15 to 1·9. The filament becomes crystalline after being in use for some time ; it blackens near the negative end, and changes through grey to a faint yellow at the positive end. There is a slight white deposit on the glass globe during the early part of its life, and this is especially noticeable with overrun lamps. Sometimes a faint hissing or singing sound is emitted by the filament, and is accompanied by a fluctuation (usually a diminution) of current, amounting to about 2 per cent. When run without globe the filament is cooled and its resistance increased by about 1 per cent. A new filament, when normally burning, has a specific resistance of 0·7 ohm per cm. cube ; after 450 hours it appears to be 1·06 ohm. The automatic switch and the heating coil are reported to work well. The author considers the average efficiency of the Nernst lamp taken throughout its life to be 2·1 watts per c.p., and compares this with an average efficiency of 3·6 watts per c.p. for the ordinary incandescent lamp. Allowing for the shorter life of the Nernst lamp, renewals cost three times as much as in the case of the glow lamp. Therefore assuming 4d. as the cost of a unit, and allowing for the cost of renewals, the Nernst lamp will furnish 1,000 c.p.-hours for 11d., which would cost 15d. with ordinary incandescent lamps. W. H. S.

REFERENCE.

2189. *The Lighting of Diversey Boulevard, Chicago.* **J. R. Cravath.** (Amer. Electn. 14. pp. 165–166, April, 1902.) L. G.

TELEGRAPHY AND TELEPHONY.

2190. *Telephone Circuits.* **J. Puluj.** (Zeitschr. Elektrotechn., Wien, 19 pp. 281–284, 1901.)—Telephone lines can, as a rule, be effectively protected against injury from lightning by means of fuses, but such fuses do not necessarily afford protection to the operators and subscribers, nor are they a complete guard against stray currents from electric light and power circuits. The author shows that a safe arrangement can be arrived at by making use of inductive coils. The sending circuit contains the microphone, the primary winding of the induction coil, a battery, and an automatic switch actuated by the telephone hook. The receiving circuit contains the secondary winding of the induction coil and the telephone. The third circuit, which is the line circuit, contains two inductive coils, one at the sending and the other at the receiving station. The first circuit and the second circuit are repeated at the second station, so that the whole arrangement is symmetrical. Diagrams of station connections and instruments are given. Safety is attained by placing the inductive coils at each station at sufficient distance from one another to ensure complete insulation between the line-coils and the telephone circuit. In order to prevent the possibility of injury to an operator or subscriber when ringing up, the electromagnetic calls are actuated by pulling a silk cord instead of by turning a handle with metal parts.

In the second part of their paper the authors show how to modify the arrangements so as to enable telephonic messages to be transmitted through electric-lighting and power circuits. In this case a condenser and fuse-wire are connected in series with the call-bell apparatus, the other end of which is connected to earth, and the other end of the condenser is connected to line. The capacity of this condenser must be made smaller in proportion as the working voltage of the power supply is greater. The authors claim that by carefully selecting the capacity of the condensers the disturbances due to dynamo fluctuations and the like can be reduced or modified so that telephonic transmission is practicable. Arrangements for use with single-phase and three-phase dynamo circuits are also described, showing how they can be adapted to the purposes of telephony. R. A.

2191. *Telephone Conduits.* **Rühl.** (Archiv Post Tele. 7. pp. 213–227, April, 1902.)—This is an account of the methods adopted in Berlin and other German towns for putting in telephone cables under streets, with special reference to economy, durability, convenience of drawing in or out, and provision of space for subsequent increase of business. As regards materials, it is shown that cast-iron compares very badly with cement. References are given to descriptive accounts of the various systems, and dimensions of some of the more important conduits are marked on the figures. Details of comparative costs of some of the Berlin systems are quoted, and other particulars relating to the weight of the blocks, tubes, and plates, together with notes on the comparative rates of construction, are added. R. A.

REFERENCE.

2192. *Telephone Service in the River Plate.* (Electrician, 49. pp. 376–379, June 27, 1902.)—Description and photographs of exchanges and subway work in Buenos Aires. J. E. K.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

DECEMBER 1902.

GENERAL PHYSICS.

2193. *Earth's Density.* **F. Richarz** and **O. Krigar-Menzel.** (International Physical Congress at Paris, Report, 4. pp. 69–73, 1900–1901.)—The values of Δ obtained by the ordinary balance (5·49–5·51), by the torsion balance (5·527), and by the Wilsing pendulum (5·577), differ from one another too much, and it may be that they could be reconciled by a proper correction for magnetic forces acting on the masses used. [See also Abstract No. 1033 (1901).] A. D.

2194. *Seasonal Variations in Rate of a Clock.* **E. F. van de Sande Bakhuyzen.** (Konink. Akad. Wetensch. Amsterdam, Versl. 11. pp. 19–43, May, and pp. 187–210, June 28, 1902.)—Observations made on the mean time clock of the Leyden Observatory show that in the course of forty years its march has continually increased in regularity. The following figures represent the mean departures from a constant value for a part of the interval investigated :—

1862–1874	±	0·0291 sec.
1879–1896		0·0237 „
1899–1902		0·0215 „

The author next notes periodical departures from the true value practically represented by a sinusoidal curve with maxima corresponding with May 1 and November 1, the semi-amplitude being + 0·0466 sec. for the interval 1899–1901. These irregularities are mathematically identical with a half-monthly lag of the influence of temperature, as long as the monthly behaviour only is considered. But this fails to afford a physical interpretation, as experiments go to show that changes in temperature are felt immediately. Nor does the hypothesis that this may be due to the elasticity of the suspension-spring acting after a certain delay only, account for these phenomena. The author therefore suggests that the temperature of the different parts of the pendulum may be permanently different, the differences varying periodically with the season. In fact, this hypothesis would seem, generally, to account for the behaviour observed, though some phenomena would hardly agree with it. A. G.

2195. *Anomalous Elastic Properties of Glass.* **E. Wandersleb.** (Ann. d. Physik, 8. 2. pp. 367–371, May, 1902. From the Jenaer Dissertation.)—The anomalous change, with temperature, of Young's modulus for glass containing antimony, observed by Winkelmann, is measured for 11 glasses in the shape

of bars 130 × 15 × 3–4 mm. Considerable differences present themselves between the stable or normal state (*n*) before warming, and the labile or accommodation state (*a*) : The values, *e.g.*, of Y_n are 0·7–2 per cent. smaller than those of Y_a ; Hooke's law holds, for the normal state, to near the breaking-point, but in the accommodation state a lagging increase of bend/stress takes place ; and the accommodation state can be changed to the normal in a short time by the vibrations of certain tuning-forks of medium pitch. Glass containing boric acid and antimony behaves abnormally, *i.e.*, Y increases with temperature, whereas glass containing antimony, but free from boric acid, behaved normally. For the abnormal condition, the maximum Y is reached at about 200°, when Y is 2 per cent. greater than at 15°. Formulæ are given expressing the normal and abnormal changes of Y with temperature. G. E. A.

2196. *Theory of Cast-Iron Beams.* **E. V. Clark.** (Inst. Civil Engin., Proc. 149. pp. 3–31, 1902.)—It is well known that a cast-iron beam will bear a much greater load than that which, according to the ordinary theory, should produce fracture. The author shows that the great discrepancy is due to various approximations made in its application to such a material as cast iron. The ordinary theory is based on the assumptions that the material obeys Hooke's law to all intensities of stress, that its modulus of elasticity is the same for compressional as for tensional stresses, and that it is homogeneous. Cast iron fulfils none of these conditions, and the effect of non-compliance with each is to raise the strength of the beam to resist fracture. The object of the experiments is to determine the forms of the stress-strain curves for cast iron (of a particular quality) ; to deduce from these the position of the neutral axis and the ultimate moment of resistance of beams of certain types of cross-section ; and to compare these calculated moments of resistance with the actual breaking moments (found by experiment) of similar beams of this quality of cast iron. Fifteen bars of cast iron were used, all cast from the same ladle ; six were used for tension and compression tests, the remaining nine (three of rectangular section, three square-on-angle, three circular) for breaking under a bending load. In the tension and compression tests, the load was applied in steps of 2,000 lbs. per square inch of section, and was never removed after being applied. Strain was measured by a Kennedy extensometer, and in tension experiments readings were taken up to the point of fracture. In compression tests strain was read up to loads of 38,000 lbs. per square inch ; no measurements of ultimate crushing stress were made. If y be the stress in lbs. per square inch, x the strain in hundredths per cent., then the results are (1) for tension, $y = 1690x - 24x^2$; (2) for compression, $y = 1690x - 7x^2$. The author then applies the equations of the tension and compression stress-strain curves to the theory of beams, obtaining expressions which give the position of the neutral axis and the modulus of resistance for beams of rectangular, square-on-angle, and circular sections. The result of using the more rigorous theory is to raise the strength of the beam to resist fracture by 41·1 per cent. for rectangular section, 57·3 per cent. for square-on-angle, and 48·9 per cent. for circular. The results of the bending tests (which were made in the usual manner, care being taken, however, that the load should never be removed after once being applied), show that with each type of beam over two-thirds of the discrepancy between the results of the ordinary theory and of experiment has been eliminated. It is to be remarked, in addition, that in the ordinary beam theory no account is taken of any stresses other than that of bending, and that severe local crushing stresses

may add somewhat to the strength of the beam to resist fracture by bending. The paper is fully illustrated by curves and tables, and concludes with a summary of the equations deduced by various writers to represent the stress-strain curves of cast iron. W. S.

2197. *Transit Theodolite for Mining Engineers.* **H. D. Hoskold.** (Inst. Mining Engin., Trans. 22. pp. 536–557; Discussion, pp. 557–566, 1902.)—A detailed description is given, with drawings and illustrations, of a theodolite to be used for connecting underground workings to the surface, *vice versâ*, and for general surveying. The lower part of the telescope stand consists of a hollow cylinder, so that a sight can be taken in the direction of the nadir, and so down a shaft by means of a side eyepiece. The method of using the instrument in a shaft, and the necessary adjustments, are fully described. The discussion, after the paper, turned chiefly on the disturbance of plumb-lines in long shafts by air currents, and the author claimed that greater accuracy was to be obtained by using his instrument or an astronomical one than by the use of plumb-lines. G. E. A.

2198. *Tide Gauges in Northern Climates and Isolated Situations.* **W. B. Dawson.** (Inst. Civil Engin., Proc. 149. pp. 3–24, 1902.)—As the tides on the eastern coasts of Canada present a remarkable range, being exceptionally high in the Bay of Fundy, and almost inappreciable in some parts of the Gulf of St. Lawrence, eight principal stations have been fitted up for obtaining continuous tide records, and twenty-eight secondary stations chiefly for summer observations. Three of the principal stations, on Anticosti Island, on St. Paul Island in Cabot Strait, and at Forteau Bay, Labrador coast, Strait of Belle Isle, are accessible only by sea, and inaccessible during five months. The wooden gauge houses contain drum, pencil, clockwork, and tide pipe and sight gauge pipe, the two pipes being placed within an iron cylinder (old boiler) about 3 ft. in diameter; this cylinder is heated by lowering petroleum lamps with three duplex burners into it. The tide float is in the tide pipe, which has a diameter of 6 in.; the sight gauge similarly contains a float to which the scale is attached; both pipes communicate with the recess, into which the sea-water enters, by strainers. It is not desired to record wave motion, and long siphon feed-pipes are used in some instances. But the still problematical secondary undulations which have a period of 15 or 20 a minute, and are particularly pronounced at stations with very small tide ranges, are recorded. The clock works with a mainspring, and a spare clock is always kept; steel springs are liable to rust and to break, and gold hair-springs have proved the most reliable. The correct time is ascertained by the observer with the aid of a dipleidoscope, consisting essentially of two small mirrors at an angle to each other, which give two images of the sun; when the instrument is set truly in the meridian, these images coincide at apparent noon. H. B.

2199. *Seiche on Loch Trieg, Scotland.* (Nature, 66. pp. 162–163, June 12, 1902.)—While engaged in the survey of Loch Trieg on May 22, 1902, T. N. Johnston and J. Parsons observed a variation in the level of the lake of an amplitude of $\frac{9}{16}$ in., with a period of 9·5 minutes. The observations were made in the evening, and appear to have lasted only 40 minutes. The lake has a length of 6 miles, a width of $\frac{3}{4}$ mile, and a depth of 436 ft. This would be the first example of a seiche in Scotland, with the possible exception of a rise and fall of the water in Loch Tay in 1784. H. B.

2200. *Seismic and Magnetic Perturbations at Uccle, Belgium, May, 1902.* **E. Lagrange.** (Comptes Rendus, 134. pp. 1325–1327, June 2, 1902.)—Earthquake movements were recorded at Uccle (triple horizontal pendulum of Rebeur-Ehlert) on the first days of May, and stronger shocks on May 6 and 8. The interval between these latter two days was quiet; assuming that the tremors would travel with a speed limited to between 800 and 1,500 m./sec., the records cannot be ascribed to the eruption of Mont Pelee on May 8, at 7.50 a.m. The magnetic perturbations of Uccle and of Louvain do not coincide with the seismic records. H. B.

2201. *New Combination Telescope Mounting and Dome.* **D. P. Todd.** (Amer. Journ. Sci. 13. pp. 459–463, June, 1902.)—A new mounting is described which the author has designed in order to permit observers to use lenses of greater focal length than any now in existence. A large spherical framework is built up of steel girders, coated with oak and sheet copper, and adjusted as nearly as possible to a symmetrical figure. This is then floated in a special tank, faced with Portland cement, and having its surface carefully scraped to the exact figure. The water used for flotation is made part of a circulatory system, and warmed in winter to prevent freezing. The objective would then be attached to a portion of the surface of the sphere, and the eyepieces, photographic apparatus, &c., at the opposite end of the diameter. The observer is suspended inside the sphere, near the eyepiece, on a swinging platform with arrangements to keep the platform always horizontal in different positions of the sphere. The various motions which are necessary for following the celestial objects are obtained by rubber-faced gear wheels on the outer surface of the sphere, control over the direction being given by a massive polar axis which is put in connection with the dome when fixed on the star. Estimates are given of details for mounting a 60-in. objective on this principle. C. P. B.

2202. *Theory of Origin of Satellites.* **L. Picart.** (Comptes Rendus, 134. pp. 1409–1412, June 16, 1902.)—The paper deals with an attempt to examine whether the satellites of the various planets were originally disconnected with the main mass, being captured by gravitational attraction after some chance approach from space. It is found that the satellites of the Earth, Mars, Jupiter, Saturn, Uranus, and Neptune cannot have assumed their present orbits in this manner. C. P. B.

2203. *Influence of Magnitude on Star Chart Reduction.* **P. Henry.** (Comptes Rendus, 134. pp. 1483–1486, June 23, 1902.)—Examples are given of the changes in reduction scale produced by plates of varying exposure. The constants for correction are obtained by making duplicate exposures on each plate, the plate being very slightly displaced along a known direction between the two exposures. The two exposures are of different duration, giving star images of different diameters. C. P. B.

2204. *Constitution of Nebulæ.* **C. Nordmann.** (Comptes Rendus, 134. pp. 1282–1285, June 2, 1902.)—After stating the chief characteristics of the phenomena presented by nebulæ, the author summarises his reasons for supposing that the principal factor in producing the luminosity of these bodies is the influence of Hertzian waves from inter-stellar space. The degree of illumination produced will depend on the various states of pressure which exist in the different regions of the nebulous mass. C. P. B.

LIGHT.

2205. *A New Direct-Vision Prism.* **W. Volkmann.** (Ann. d. Physik, 8. 2. pp. 455–458, May, 1902.)—This is pentagonal in shape, and a ray, parallel to the base, entering an upper face, undergoes two internal reflections and passes out through the other upper face in the original direction, the angle of incidence being $(1 + \sqrt{8\mu^2 + 1})/4\mu$. The prism has been patented in England, Germany, and Austria. A new prism for liquids is made by forming a trough, equilateral in section, with two interior reflecting surfaces. The ray passing through the liquid surface is twice reflected internally and again passes out through the surface. G. E. A.

2206. *Image of a Plane formed by a Prism.* **R. Straubel.** (Ann. d. Physik, 8. ". pp. 63–80, April 29, 1902.)—The planes here referred to are assumed to be small compared with their distances from the prism. In a previous paper [see Abstract No. 243 (1899)] the author treated the question on the assumption that an infinitely small pencil of rays proceeding from a point at finite distance remains homocentric after traversing a prism with minimum deviation. In this case it appeared sufficient to consider a section of the pencil by the principal plane of the prism. The assumption, however, neglects the length of path in the prism. When this is considerable the emergent pencil is generally not homocentric, the astigmatic difference varying directly as the length of path in the prism. The angle between the primary and secondary image surfaces corresponding to one object plane depends on the ratio of these two quantities. The author therefore extends his former reasoning to a sagittal section. Object and image planes are supposed to be parallel to the edge of the prism, and the axis of the small pencils considered, to lie in a principal section of the prism. But the axes need not pass at minimum deviation, and the incident pencil may be already astigmatic if the focal lines are respectively parallel and perpendicular to the prism edge. The two following equations are obtained connecting the inclinations of object and image planes—

$$\tan \nu' \cdot \frac{\cos r_2}{\cos i_2} - \tan \mu' \cdot \frac{\cos r_1}{\cos i_1} = \frac{(n^2 - 1)\sin \alpha}{n \cos r_1 \cos r_2} \cdot \frac{1 - \sin i_1 \sin i_2 \cos (r_1 - r_2)}{\cos^2 i_1 \cos^2 i_2}$$

$$\tan \nu'' \frac{\cos i_2}{\cos r_2} - \tan \mu'' \cdot \frac{\cos i_1}{\cos r_1} = \frac{(n^2 - 1)\sin \alpha}{n \cos r_1 \cos r_2}.$$

Here the letters with a single dash refer to principal, those with a double dash to sagittal, sections. The μ's and ν's denote the obliquities of the object and image planes to the rays; i_1, r_1, r_2, i_2 the angles between the ray and the normals to the faces of the prism in order, α is the angle of the prism, and n the index.

The following are among the consequences deduced: (1) In each section the obliquities of object and image are generally different, but for every inclination of the ray a pair of conjugate planes can be found whose obliquities are in a given ratio. The corresponding case for minimum deviation is when the planes are *parallel* to the pencils. (2) An orthogonal object never gives an orthogonal image. Several pages are occupied by discussion of the boundary conditions ($\tan \mu'' = 0$ and $\tan \nu'' = 0$); and curves with ν', ν'' as

ordinates and i as abscissa are given, showing how the inclination of the image varies with the angles of incidence. The possibility of homocentric and erect representation of an inclined object plane is discussed ($\mu' = \mu''$, and $\tan \nu' = 0 = \tan \nu''$), and it is found that small obliquities of the object can only be corrected by prisms of small angle and index nearly = 2. A. E.

2207. *Focal Lines in Isotropic Media.* **H. Bouasse.** (Journ. de Physique, 1. pp. 201–207, April, 1902.)—A proof is given of Sturm's theorem of focal lines, using a geometrical surface and its normals instead of rays of light. It is shown that, if a surface of revolution be taken, the pencil of normals to any element of the surface passes rigorously through an element of the axis of the surface, and that this element of the axis is not a focal line. G. E. A.

2208. *Optical Demonstrations by means of a naturally Curved Surface.* **J. J. Taudin Chabot.** (Phys. Zeitschr. 3. pp. 331–332, May 1, 1902.)—A glass cylinder containing mercury is rotated on a whirl-table, and various simple optical experiments are performed by hanging an electric lamp above the revolving mercury and interposing smoke to show the path of the rays. A fluorescent liquid can be substituted for the mercury to exhibit refraction effects. G. E. A.

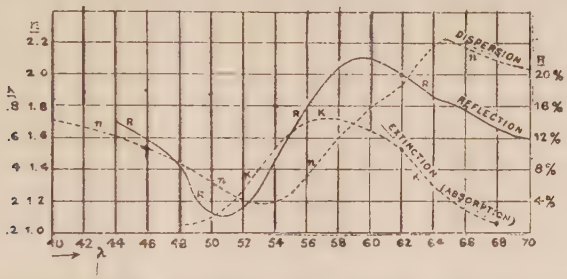
2209. *Surface Colour.* **R. W. Wood.** (Phys. Rev. 14. pp. 315–318, May–June, 1902.)—Optical text-books contain misleading statements regarding the phenomenon of surface colour exhibited by certain strongly absorbing media; for instance, that these substances reflect most strongly those colours which they most strongly absorb. One of the more recent advanced books refers the phenomenon to total reflection, due to the index being less than unity. As a matter of fact it falls below unity only in the case of a very few substances. Moreover the selective reflection occurs at normal incidence. The statement that the most strongly reflected light corresponds to the light absorbed is erroneous. Take cyanine as an example. The centre of the absorption band is very near the D lines, but the surface colour is not yellow but a deep plum colour, not so very unlike the transmitted light. On examining the spectrum of the reflected light we find a very dark band in the green, the centre being near wave-length 0·50; while the distribution of intensity in the rest of the spectrum is not very different from what it would be in the case of reflection from glass. This shows that the peculiar colour of the dye is not so much due to a very powerful reflection of certain waves as to its almost complete refusal to reflect certain other waves. Remembering that reflecting power depends on index as well as on the coefficient of absorption, this behaviour can easily be explained. The intensity of the light reflected at normal incidence is given by the formula—

$$R = \frac{n^2 + n^2k^2 + 1 - 2n}{n^2 + n^2k^2 + 1 + 2n}$$

[k being the coefficient of absorption]. In absorbing media the index varies much more than in transparent substances, consequently greater variation in reflecting power is to be expected, apart from the fact that the absorption influences R directly. Taking Pflüger's values of n and k for cyanine, the author has calculated the percentages reflected in the cases of the different wave-length.

The accompanying curve was thus obtained; it shows clearly the cause

of the peculiar surface colour of the dye. Starting from the red end, we find that the intensity of the reflected light first increases owing to the joint increase in n and k. The increase continues after n begins to decrease owing to continued increase of k. After reaching a maximum at $\lambda = 0{\cdot}59$, it turns and descends rapidly to a minimum at $\lambda = 0{\cdot}50$, where the values of both n and k are very small. Beyond this point the rise is due to increase in n, since k is practically zero in this region. Scarcely 2 per cent. of the incident light is reflected at $\lambda = 0{\cdot}50$, which explains the dark band in the green alluded to above. An excellent way of showing the variable reflecting power of a film of cyanine is to compare it with glass in different parts of the spectrum. A little of the melted dye is pressed between two plates of hot glass, which

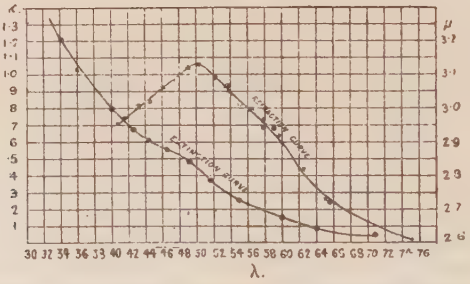


are separated when cold. A spot is selected where the film has a good surface, and this spot is left on the glass, the rest being cleaned off. The plate is then held in a spectrum. In some regions of the spectrum the cyanine reflects more strongly than the glass, while at $\lambda 0{\cdot}50$ the film appears as a black spot on the blue field reflected by the glass. It is interesting to note the difference in surface colour of the cyanine when the reflection takes place at the surface in contact with the glass. A convenient way of showing the yellowish-green colour in this case is to press out a film of the molten dye on one surface of a prism of 8° or 10° angle. The light reflected from the first glass surface is thus thrown out of the way. A suitable prism can be made in half an hour by grinding down a piece of thick plate window glass. A. E.

2210. *Absorption, Dispersion, and Surface Colour of Selenium.* **R. W. Wood.** (Phil. Mag. 3. pp. 607–622, June, 1902. Paper read before the Physical Society, Feb. 28, 1902.)—The dispersion curves of substances with absorption bands in the visible or infra-red spectrum have been much studied, but scarcely any work has been done on those whose absorption begins in the visible region and extends far into the ultra-violet. The author selected amorphous selenium as a type of these media. He first studied its dispersion by direct spectrometer measurements with prisms of the substance. Selenium is much more transparent than cyanine, and prisms of 4° or 5° could be employed, which were made by squeezing small pieces, heated to fluidity, between two glass plates. It was found impossible to construct prisms of small enough angle to make determinations for smaller wave-length than $0{\cdot}61\ \mu$ feasible. The curve was therefore followed further towards the violet by means of the interferometer in the manner described in previous papers on cyanine and carbon. Uniform selenium films on glass plates were employed in the first place, but in the blue only exceedingly thin ones let any light through. Wedge-shaped films were therefore adopted, which were obtained by shielding the plate during the deposition with a strip of mica at one side. Curved fringes were thus obtained which would allow the displacement for

any wave-length to be measured for the maximum thickness capable of transmitting the light. Another advantage of the wedge-shaped films is that the displaced fringes can be identified with the undisplaced. The values of the indices obtained in the red by means of the prisms were taken as a basis for the calculations from the interferometer results. The dispersion curve obtained is shown in the figure ("refraction curve"). The turning-point is at λ·50, where the index reaches the value 3·13, the highest value ever found for any substance. The continued rise of the dispersion curve after entrance into the region of the absorption band (near the D line) is worthy of notice, for usually the curve falls abruptly as soon as the band is entered. Whether the displacement of interference-fringes gives a true measure of index in the case of films whose thickness is less than the wave-length of light, is a question not yet settled. A refraction curve for selenium is given by Ketteler in his "Theoretical Optics," p. 552, which must be wrong in the red and orange if it refers to the glassy, and not the metallic modification. To obtain the extinction curve the absorption was measured by the aid of photography, a part of the photographic plate being exposed to light which had passed through the selenium film, and a part to light coming through clear glass, or quartz in the case of the ultra-violet. For the visible spectrum a spectrophotometer was employed, with the double slit replaced by a single slit, the

Fig 4



photographic plate being mounted behind the ocular slit. For the ultra-violet a concave grating by Thorp was used instead. It was made by mounting one of his celluloid replicas of a Rowland grating on a concave lens, the celluloid film being silvered. On somewhat reducing the aperture it gave surprisingly sharp images. The extinction curve is not to be taken as very accurate, but the fact was fully established that the curve is still rising rapidly at λ·22, where the coefficient is as high as in metals. A possible turning-point might, however, be masked by a high reflection coefficient. It is probable that we have to deal, not with a single absorption band, but with a series of overlapping bands. The infra-red transmission was examined down to 2·3 μ with a very sensitive bolometer, and no absorption bands were found. A search for traces of selective absorption in the ultra-violet had negative results. Selenium shows a strong surface-colour if the incidence is near the polarising angle, and the reflected light examined through a nicol turned to extinguish it as much as possible. The colour ranges from greenish-white through blue to deep violet. At present the author is investigating nitroso-dimethyl aniline, a substance of remarkable behaviour. It crystallises in green laminæ, which melt at 85°, and can be formed into fluid prisms, which become opaque when solid. Pressed into a thin film it seems nearly as transparent as pale yellow glass, but with the spectroscope the blue end of the spectrum is seen cut off almost as sharply as by a screen. The author was assisted in the above researches by A. H. Pfund. A. E.

2211. *Luminous Sensation a Function of the Time.* **A. Broca** and **D. Sulzer.** (Comptes Rendus, 134. pp. 831–834, April 14, 1902.)—A luminous sensation passes through a maximum which is more quickly reached the brighter the light is (say from 0·04 to 0·2 seconds), and falls to a permanent value which is also more quickly reached the brighter the light is (say from 1·1 to 2·5 seconds). The ratio between the maximum and the permanent value is greater the brighter the light is (say from 5·5 to 1·12). A. D.

2212. *The Majorana Effect.* **W. Voigt.** (Accad. Lincei, Atti, 11. pp. 505–507, June 15, 1902.)—Majorana has described [See Abstract No. 1844 (1902)] a magneto-optic phenomenon analogous to the acquisition of double-refracting properties by a dielectric under electric stress. Voigt here gives a theoretical explanation on lines similar to those which he has followed in dealing with Kerr's electrostatic effect. W. S.

2213. *Magnetic Rotation in Liquefied Gases, II.* **L. H. Siertsema.** (Konink. Akad. Wetensch. Amsterdam, Versl. 11. pp. 250–255, June 28, 1902.)—The author, continuing his researches in magnetic rotation with an improved apparatus, finds the constant of magnetic rotation in the case of liquefied CH_3Cl under atmospheric pressure, and for sodium light, to be 0·01372, the rotatory dispersion being normal, and differing but little from the one observed with gases and water. [See also Abstract No. 842 (1902).] A. G.

2214. *The Band Spectrum of Nitrogen.* **G. Berndt.** (Ann. d. Physik, 7. 4. pp. 946–948, April 8, 1902. Paper read before the Physikalischen Institut zu Halle.)—In the band spectrum of nitrogen obtained with the oscillating spark discharge, and in that from the negative pole in Geissler tubes, the group arrangement is the same. The wave-lengths in both agree together. The distribution of intensity, on the other hand, is a completely different one. Hence it follows that of the bands from the Geissler tube by far the most are not resolved with small dispersion, whilst those obtained from the oscillating spark discharge are split up into single lines with comparative ease. J. J. S.

2215. *New Heads to Cyanogen Bands.* **C. C. Hutchins.** (Astrophys. Journ. 15. pp. 310–312, June, 1902.)—The author claims to have discovered new heads to bands in the cyanogen spectrum at $\lambda = 3914{\cdot}47$, $\lambda = 4278{\cdot}50$, and also of a new head to the band at $\lambda = 4606$, but of this he is doubtful. The bands were obtained with metallic poles with arc and spark. The fact that these heads belong to cyanogen appears rather doubtful, especially as moistening the poles with oil has no effect on them, while the known cyanogen bands are greatly increased. Possibly they are due to Basquin's hydrogen-metallic spectra. [See Abstract No. 677 (1902).] E. C. C. B.

2216. *Transparency of Matter to Röntgen Rays.* **L. Benoist.** (Soc. Franç. Phys., Séances, 3. pp. 204–219, 1901.)—From his investigations on the varying degrees of transparency towards Röntgen rays of different bodies, the author is led to state certain definite laws. He found previously that the *specific opacity*, or the absorbing power of unit mass, in general increased rapidly with the density, and depended on the state of the Röntgen-ray tube employed, that is, on the nature of the rays given out. In the investigation here described the author made use of the fluorescent screen method.

The following are the laws of the phenomena which he has arrived at: (1) The specific opacity of a body for a given quality of Röntgen rays and for a determined standard thickness is independent of the physical state of the body. Thus the same value holds for water and for ice, for solid iodine and for iodine vapour. This statement differs from the results arrived at by other observers whose observations the author criticises. The law stated applies to variations due to changes of temperature, and to crystalline and amorphous states of the same substance. (2) The specific opacity of a body is independent of the atomic or molecular mode of grouping, *i.e.*, of allotropy in simple bodies or polymeric modifications in compounds. The yellow and red varieties of phosphorus have the same equivalent of transparency. (3) The specific opacity is independent of the state of freedom or of combination of the atoms. This may be stated in the following equation:—

$$\frac{M}{E} = \Sigma \frac{m}{e},$$

where M is the total mass of the compound or mixture, E its equivalent of transparency, m the mass of one of the contained elements, and e its equivalent of transparency. (4) The specific opacity of simple bodies, measured under well-defined conditions, is a determinate function of their atomic weights and generally increases with the atomic weight. This law the author expresses by means of a curve which is given in his paper, its equation being of the form—

$$E = A + \frac{B}{p} + \frac{C}{p^2}$$

The specific opacity for Röntgen rays is considered to constitute a new additive property of matter, like mass, atomic weight, &c. Each curve of equal transparency qualifies in a precise manner a definite group of Röntgen rays, and these may be put under the heads of Röntgen-rays, secondary rays, tertiary rays, rays of uranium, radium, &c. The Röntgen-ray tubes may also be classified. The author suggests that the Röntgen-ray constants may be used for the determination and verification of atomic weights, and that the varying transparency for Röntgen rays may also be used to recognise certain mixtures and to detect frauds and adulterations in various alimentary or industrial products. J. J. S.

2217. *Stereoscopic Radiology.* **T. Guilloz.** (Comptes Rendus, 134. pp. 1303–1305, June 2, 1902.)—When the conditions are truly stereoscopic, there is a remarkable power of dealing with the distances of the different parts of the image, and a measuring rectangular network of wire can be brought into coincidence with any plane of the image. When not, there are serious illusions; described. A. D.

REFERENCE.

2218. *Finsen's Lupus Treatment.* **Kattenbracker.** (Röntgen Ray, Archives, 6. pp. 89–92, April, 1902.)—An account is given of Kjeldsen's iron-electrode arc lamp for lupus, and of bactericidal experiments with it at Aufrecht's Institute, Berlin. A. D.

HEAT.

2219. *New Form of Recording Apparatus for a Roberts-Austen Electrical Pyrometer.* **E. A. Lewis.** (Soc. Chem. Ind., Journ. 21. pp. 844–845; Discussion, p. 845, June 30, 1902.)—The ordinary recording drum turns by clockwork once in 6, 12, or 24 hours. The author has designed a smaller drum, which is connected with a pulley, round which passes a cord attached to a float; as the float falls it turns the drum once in from five minutes to an hour, according to the adjustment. This smaller drum is suitable for recording the cooling curves of small quantities of metals cooling in a crucible.

D. H. J.

2220. *Liquefaction of Air.* **G. Claude.** (Comptes Rendus, 134. pp. 1568–1570, June 30, 1902.)—The author uses a modified Linde apparatus, with the important difference that the escaping gas is made to perform external work which is absorbed by a dynamo. The paper describes the modifications in the apparatus since September, 1900. In the latest form the machine works at a pressure of 28 to 30 atmospheres, developes a useful power of 6–7 h.p., and furnishes 20 litres per hour of liquid air. R. S. W.

2221. *Melting-point of Manganese.* **W. C. Heraeus.** (Zeitschr. Elektrochem. 8. pp. 185–187, April 3, 1902.)—The melting-point of manganese is difficult to determine accurately, owing to the ease with which the metal combines with oxygen and other gases at high temperatures. Two methods, used in determining the melting-points of metals by Professor Holborn, of Charlottenburg, were found to be unsuitable on account of the necessity of excluding oxygen completely, and the difficulty of fusing a piece of the metal on to the ends of a Le Chatelier thermocouple. The author used his new electric furnace [see Abstract No. 2295 (1902)]. The requisite temperature is obtained by varying the resistance in circuit, and can be kept very constant. Hydrogen, dried and carefully freed from any trace of oxygen by passing through alkaline pyrogallate, was found to be the only gas not attacked by melting manganese; carbon dioxide was decomposed, and nitrogen combined with the metal at 1,210° C. with production of flame. Further difficulties were experienced in choosing a substance on which to melt the manganese; porcelain, lime, and electrically melted magnesia were useless, and finally pure alumina was employed. The following temperatures were obtained for the melting-point of manganese (99 per cent. Mn): 1,240°, 1,245°, 1,240°, 1,265°, 1,240°, 1,250° C. The fourth determination is probably too high, owing to the presence of moisture. W. C. B.

2222. *Vapour Pressures and Boiling-points of Mixed Liquids.* **S. Young.** (Chem. Soc., Journ. 81. and 82. pp. 768–776, June, 1902.)—The author considers that a decision might be formed as to what constitutes the normal behaviour on distillation of a mixture of liquids which are miscible in all proportions, by studying closely related substances like chlorobenzene and bromobenzene. He has already shown that many simple physical relations exist between these bodies, for which the critical points are the same and for

which there is a constant ratio of the boiling-points on the absolute scale; he now shows that there is no heat or volume change on mixing. The boiling-points of several mixtures were determined at pressures varying from 685 mm. to 789 mm., and the results were found to be in accurate accordance with the law which van der Waals (modifying a formula of Guthrie's) proposed for the case of two liquids having the same critical point and according with the equation $a_{1.2} = \sqrt{a_1 . a_2}$ (Galitzine, Berthelot), where $a_{1.2}$ represents the attraction of the unlike, a_1 and a_2 of the like molecules. Van der Waals' law may be stated thus: The relation between the vapour pressures and the molecular composition of mixtures of such substances is represented by a straight line, or $P = p . P_A + (100 - p) P_B/100$, where P, P_A, and P_B are the vapour pressures of the mixture and of the two pure components A and B, at the same temperature, and p is the molecular percentage of one of them.

D. H. J.

2223. *Corrected Specific Heats, and Latent Heats of Vaporisation for some Organic Substances of High Boiling-point.* **W. Louguinine.** (Annal. Chim. Phys. 26. pp. 228–247, June, 1902.)—The author, working with his perfected arrangement, has made further redeterminations of specific and latent heats; incidentally he has determined the vapour densities of some of the substances at temperatures near the boiling-point. The results are given in the following table:—

Substance.	Sp. Heat.	Lat. Heat.
Methyl hexylacetone	0·5723	71·11
Ethylene glycol	0·6808	190·90
Benzyl alcohol	0·5579	98·46
Benzaldehyde	0·4453	86·55
Diethyl oxalate	0·4818	67·58

The specific heats given are mean values for temperatures between 20° (about) and a temperature not higher in any case than 195°.

An application of Trouton's ratio to the data for the above substances proves the absence of polymerisation in the liquid state in all cases except one (ethylene glycol).

D. H. J.

2224. *Theory of the Critical Phenomena and of Evaporation.* **J. Traube.** (Ann d. Physik, 8. 2. pp. 267–311, May, 1902.) [See also Abstract No. 1445 (1900).]—Attention is called to certain facts which cannot be explained by the simple theory of the critical phenomena advanced by Andrews. It appears now to be fully established that in a large number of cases the liquid and vapour layers do not at once become identical when the critical temperature is reached; at this temperature the two layers become completely miscible, and if the tube containing the substance be frequently shaken nothing abnormal can be noticed; but if the tube be kept at rest the upper and lower layers only gradually become identical when the critical temperature is reached, especially if the temperature is not raised much above the critical. The gradual inter-diffusion of the two layers has been noticed by a large number of observers, including the author, whilst Hannay and Hogarth have rendered it easily visible by dissolving eosin, and Cailletet and Colardeau by dissolving iodine in the liquid. Differences of refractive index, appearing abruptly at what was

previously the boundary of the liquid and vapour layers, have been noticed by Ramay, and have been measured by Galitzine, who found the difference between the refractive index of the two phases of ethyl ether to be six times as great above as below the critical temperatures. Ramsay, Battelli, and de Heen have shown that unless the critical temperature has been considerably exceeded or the heating prolonged for more than half an hour, condensation occurs only in that part of the tube which was previously occupied by liquid, and Guye has found that in the case of carbon dioxide cooling from above the critical temperature equilibrium between the two phases is not established for more than a week, and that during this time the meniscus is gradually displaced through several centimetres. Differences in density have been observed by Cailletet and Colardeau by means of an O-tube containing carbon dioxide and sulphuric acid, whilst de Heen and Dwelshanvers-Dery have shown that above the critical temperature the density of the gas depends not only on the pressure and temperature, but also on its previous history, *i.e.*, whether it was formed from the liquid or vapour layer; this difference of density may amount in the case of carbon dioxide to as great a ratio as 1 : 2·16; the difference of density persists considerably above the critical temperature of carbon dioxide (31°), and it is only at 60° that the gas begins to possess a determinate density.

To explain these phenomena the author assumes that two kinds of molecules exist—"gasogenic" and "liquidogenic"—that the liquid contains a proportion of gasogenic molecules gradually increasing from 0 at the absolute zero until, at the "absolute gas-point," which may be several degrees above the critical temperature, "liquidogenic" molecules can no longer exist, and the substance exists wholly in the "gasogenic" form. Similarly it is supposed that the saturated vapour contains a steadily increasing proportion of "liquidogenic" molecules until at the critical temperature the proportions become identical in the two layers and the meniscus disappears. It is supposed, however, that equilibrium between the two kinds of molecules is only established after an interval of time, and the proportions in the two layers would only slowly become identical. The critical temperature is then a stable "triple-point," and corresponds exactly with the critical temperature at which liquids such as water and phenol become completely miscible. The absolute volume b of a gram molecule of the gas can be deduced from van der Waals' equation $(p + \frac{a}{v^2})(v - b) = RT$, whilst the minimum volume of a gram molecule of liquid at the absolute zero can also be calculated from the density curves of liquid and saturated vapour [see Abstract No. 1439 (1900)]. From these values the conclusion is drawn that the absolute volume of the gasogenic molecules is double that of the liquidogenic molecules—a result in accordance with the observations of de Heen and Galitzine on the density and refractive index of the two layers of the substance which persist above the critical temperature. In the case of monatomic mercury, however, the b values are almost absolutely steady from the lowest temperatures up to 350°, and here, perhaps, only one kind of molecule exists. In the case of most liquids the proportion of gasogenic molecules is calculated to be about 9 per cent. at the ordinary boiling-point. Calculations are also made of the heat required for converting one gram molecule of substance from the liquidogenic to the gasogenic condition; the values range from 4,500 to 7,200 cal.

From the standpoint of his theory the author seeks to deduce a new view of the osmotic phenomena, by assuming that each molecule of a non-electrolyte combines with a single gasogenic molecule, whilst binary electrolytes are

assumed to combine with two molecules and ternary electrolytes with three molecules. In this way he accounts for the observed lowering of vapour pressure, but no attempt is made to explain the accompanying electrical phenomena. T. M. L.

2225. *Correlation of Latent Heat of Evaporation with Vapour Density.* **W. Kurbatoff.** (Jurn. Russk. Fisik. Chimičesk. Obščestva, 34. 3a. pp. 250–287, 1902.)—The author describes a method of determining the latent heat of evaporation in the case of readily gelatinising substances. This method is applied to hydrochloric aniline with varying pressures; the total thermic capacity and the thermic capacity of the liquid substance are also measured, and a method of eliminating the influence of the time of transport from the heater to the calorimeter is suggested. Hydrochloric aniline is found to be totally dissociated at 244° and 760 mm., whereas, at a temperature 15° below, 10 per cent. of the chlorhydrate is undecomposed, the liquid studied thus being capable of conserving undecomposed molecules in the vapour in a manner analogous to ammonia. It results from the theory as well as from the experimental data, that Trouton's law is common to all liquids. The true molecular weight of the vapours is determined, the values found being either normal or too high, the latter pointing to a dissociation of the body taking place. The dissociation corresponding to the liquid phase proves to be very small, and Linebarger's constant is found not to be true. A. G.

2226. *Calorimetric Determination of Curve of Fusion.* **A. Wyschneslawzew.** (Jurn. Russk. Fisik. Chimičesk, Obščestva, 34. 3b. pp. 41–48, 1902.) —The author describes a modification of de Visser's method of determining the form of the curve of fusion by calorimetrical measurements (Zeitschr. Phys. Chem. IX., p. 767, 1892), this modification requiring much smaller quantities of the substance than the original device. The values of the quotient $\Delta v/\Delta r$, where v is the volume and r the heat of fusion, are determined for naphthaline, phenol, ortho-nitrophenol, ortho-cresol, and trimethyl-carbyl; and the values of the differential quotient dt/dp, as calculated from the same by multiplying by ET, are compared with those found by direct experiment for the three former, the agreement being a most satisfactory one. A. G.

2227. *van der Waals' ψ-Surface, III.* **J. E. Verschaffelt.** (Konink. Akad. Wetensch. Amsterdam, Versl. 11. pp. 255–269, June, 1902.)—The author studies the state-equation and the ψ-surface in the immediate neighbourhood of the critical state for binary mixtures with small percentages of one of the components. The p, v, T diagram is first given for a homogeneous substance; the system of isothermals of a mixture such as defined above is next found by performing an infinitely small parallel displacement and expansion of the one of the pure substance, the critical point being shifted on to the critical point of the undecomposed mixture. Van der Waals' ψ-surface is subsequently considered, the coexisting phases, the plait-point, the projection of the connodal line on the x, v-surface, and the critical point of contact being the elements investigated more especially. [See also Abstract No. 1745 (1902).] A. G.

2228. *Evaluation of van der Waals' Constants, II.* **P. A. Guye** and **L. Friderich.** (Archives des Sciences, 13. pp. 559-568, June, 1902.)—In continuation of a former paper [see Abstract No. 2006 (1900)], the values of a and b for 22 more substances are calculated from the experimental determinations of the critical temperature and pressure. Obvious modes of

estimating the really varying values of a and b with temperature are also given, and for isopentane the following values, referred to the gram-molecule, are calculated ; the values found by the other method being $a = 1{\cdot}833 \times 10^7$, $b = 143{\cdot}6$.

t° C.	Liquid.		Vapour.	
	a	b	a	b
10	$1{\cdot}130 \times 10^7$	87·6	$5{\cdot}878 \times 10^7$	1260
30	$1{\cdot}154 \times 10^7$	88·2	$4{\cdot}063 \times 10^7$	415
50	$1{\cdot}187 \times 10^7$	89·1	$3{\cdot}674 \times 10^7$	428

R. E. B.

2229. *Thermal Properties of Carbon Dioxide and of Ethane.* **J. P. Kuenen and W. G. Robson.** (Phil. Mag. 3. pp. 622–630, June, 1902.)—From their low-temperature determinations of vapour pressure [see Abstract No. 1079 (1902)], the authors conclude that for carbon dioxide (1) the law of corresponding states is obeyed within the same limits as by the non-associating substances ; (2) the density diameter, which is practically straight for temperatures above 0°, is for lower temperatures slightly convex to the temperature-axis ; (3) the latent heat of vaporisation has no maximum value as according to Mathias's formula ; (4) at the triple point (— 56·24° C. under pressure 5·1 atmos.) the specific volumes of the vapour, liquid, and solid may be taken as 74, 0·850, 0·676, the latent heats of vaporisation, fusion, and sublimation as 86·1, 43·8, 129·9, and the corresponding values of dp/dt, 0·224, 47·9, 0·337 ; (5) the latent heat of sublimation increases as the temperature rises. For ethane estimations of the specific volumes and latent heats of vaporisation are given, but the data are more uncertain than for CO_2.

R. E. B.

2230. *Rupture and Displacement of Equilibrium.* **Jouguet.** (Comptes Rendus, 134. pp. 1418–1420, June 16, 1902.)—The conditions of equilibrium under a series of circumstances of a system without viscosity, and of which we may neglect the inertia, are here deduced, especially for adiabatic modifications. R. E. B.

2231. *Certain Laws of Radiation.* **E. Kohl.** (Ann. d. Physik, 8. 3. pp. 575–587, June, 1902.)—The writer proposes to prove Stefan's law of radiation, and the Bartoli-Boltzmann law, as deductions from the results obtained by Wien as to radiation from a moving surface. Following Wien in principle, he supposes a cylinder of length $a - x$, its curved surface and one of its flat ends being perfectly reflecting and impervious to heat, while the other flat end is filled by a body of very small thickness at temperature θ, which radiates only into the cylindrical space. The total radiation energy within the cylinder is proportional to the length $(a - x)$ of the cylinder, and to a function, $\psi(\theta)$, of θ. It may be divided into separate portions according to the wave-length. The assumption is fundamental that the density of radiation, and therefore also the energy, depends only on the temperature

of the radiating surface, and not on its physical nature. It is, therefore, the same as if the radiating surface were a perfectly black body. The radiating surface being moved slowly so as to diminish $(a - x)$ by dx, it is shown by Wien's method that ρ, the frequency of vibration for any wave, undergoes change, becoming $\rho dx/3(a - x)$. Also that θ and the energy E change according to the formula $dE/d\theta \,.\, d\theta = Edx/3(a - x)$. This increase of energy implies a pressure on the radiating surface in accordance with the law of Bartoli and Boltzmann, which thus appears as a deduction from Wien's work. The writer then proceeds to thermodynamical considerations. We have, by the second law, the relation $(A + Q)\theta' - \theta/\theta' = A$, in which A is a quantity of work converted by the usual reversible process into heat at temperature θ', while a quantity of heat Q is raised from temperature θ to θ'. Applying this formula to the preceding problem, he obtains the relation $a - z = a\theta_0^3/\theta^3$, which gives for the energy $\psi(\theta) = C\theta^4$ where C is a constant. This expresses Stefan's law, already established on theoretical grounds by Boltzmann and Wien, and recently by Larmor [see Abstract No. 503 (1901)]. The investigation has proceeded on the assumption that the processes are reversible, which would not be the case if the radiating surface absorbs heat. This was the reason for making it infinitely thin as stated above. It is shown that it is sufficient for the purpose to assume that heat is supplied from without to the radiating surface so as to maintain it in thermal equilibrium with the cylindrical space. From the equations already obtained between ρ and θ, the writer further deduces the most general form of the relation between density of energy and frequency ρ, which satisfies Stefan's law in the form—

$$\psi(\rho\theta)d\rho = C\rho^3\phi\left(b\frac{b}{\theta}\right)d\rho$$

This is subject to the unknown function ϕ. From the last equation the author deduces Wien's law for the relation between θ and the maximum intensity. It is pointed out that the investigation also rests on Boltzmann's assumption that the radiation can be resolved into three mutually perpendicular components. The concluding section deals with the consequences that would follow if the alteration of ρ due to the motion of the radiating surface had a different form—if, instead of ρ becoming $\rho\{1 + dx/3(a - x)\}$, it became $\rho\{1 + mdx/(a - x)\}$, where m is a constant. S. H. B.

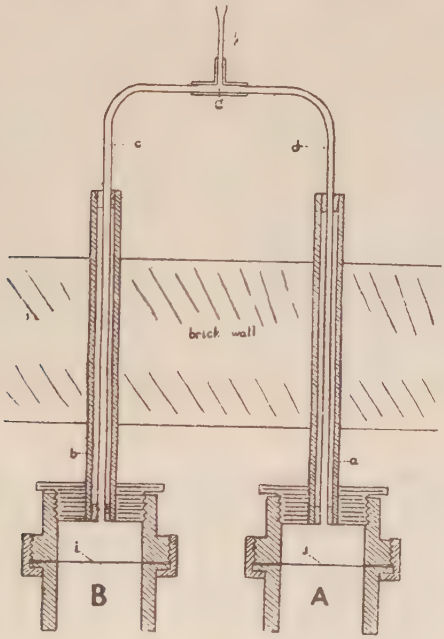
REFERENCES.

2232. *Monatomic Gases.* **D. Berthelot.** (Soc. Franç. Phys., Séances, 3. pp. 195–198, 1901.)—This is the complete paper referred to in an abridged form in Abstract No. 1655 (1901). R. E. B.

2233. *Denizot's Deduction of the Second Law of Thermodynamics.* **W. Voigt.** (Ann. d. Physik, 8. 2. pp. 472–473, May, 1902.)—The fallacy of Denizot's reasoning [see Abstract No. 1333 (1902)] is here pointed out, as already indicated in the Abstract. R. E. B.

SOUND.

2234. *Transmission of Sound through Solid Walls.* **F. L. Tufts.** (Amer. Journ. Sci. 13. pp. 449–454, June, 1902.)—Experiments are described upon the transmission of sound through materials impervious to air, and it is found that such transmission takes place, not as an elastic wave, but as a to-and-fro vibration of the wall itself. The apparatus used is shown in the diagram. In the 8-in. brick wall is placed the bifurcated system of piping shown. The observer places his ear at *h*, and the sound-wave (caused by dropping a



metal ball upon a pine board) strikes the discs shown at A and B. By alternately opening and closing the rubber tubes *c* and *d*, the observer can easily ascertain which of the two discs transmits the louder sound. Discs of lead, pine, brass, cardboard were experimented upon, their rigidities being also measured. It is found that in all cases the amount of sound transmitted as an elastic wave is negligible in comparison with that due to the vibration of the disc as a whole. The effect of mass is small in comparison with that of rigidity. J. W. P.

REFERENCE.

2235. *Sounding-Flames and Flame-Telephony.* **H. T. Simon** and **M. Reich.** (Phys. Zeitschr. 3. pp. 278–285 ; Discussion, pp. 285–286, April 1, 1902. Paper read before the 73rd Naturforscherversammlung at Hamburg.)—A historical *résumé* of the whole subject of sounding arcs and photo-telephony. A. D.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

2236. *Production of a Magnetic Field by a Flight of Charged Particles.* **R. W. Wood.** (Phil. Mag. 3. p. 659, June, 1902.)—In Rowland's experiment on electric convection, and in the later modifications of it, centrifugal force places an upper limit upon the attainable velocity of the moving charge. To avoid this the author has abandoned the rotating disc, and uses a flight of charged particles. The present paper is merely a note explaining the preliminary experiments and the positive results obtained from them. By driving a cloud of charged particles of solid carbon dioxide through a long glass tube placed under a magnetic needle, a deflection was obtained. The particles become charged in the same manner as the steam-jet in Armstrong's hydroelectric machine, the potential being so high that sparks over a centimetre long can be drawn from the iron cylinder containing the liquefied gas. Reversing the direction of the jet reverses the direction of the deflection. With two tubes side by side, about 1·5 m. long, and contained in a larger tube, with the remaining space filled with paraffin, two jets from separate cylinders can be sent simultaneously in opposite directions, and if the needle is first deflected by one jet, it can be brought back to zero by setting the other jet in action. The particles appear to be positively charged, and the direction of the deflection is the same as when an electric current flows from the carbon to the zinc in the direction of the gas-jet. Further experiments, going into details and examining the phenomenon more minutely, are now in progress.
W. C. H.

2237. *Electric Force due to Magnetic Variations.* **E. Carvallo.** (Comptes Rendus, 134. pp. 1349–1352, June 9, 1902.)—Crémieu's negative results [see Abstracts Nos. 56 and 316 (1902)] are quite what were to be expected from the conditions of his experiments, and are in accord with Maxwell's principles. **Crémieu** (pp. 1423–1425, June 16, 1902) replies and says he had anticipated M. Carvallo's points in earlier experiments, now more fully described ; and he adheres to the position that there are no electric forces generated in dielectrics by magnetic variations.
A. D.

2238. *Statistical Electro-Mechanics.* **van der Waals, Jr.** (Konink. Akad. Wetensch. Amsterdam, Versl. 11. pp. 79–88, May, and pp. 243–250, June, 1902.)—In a recent work, Gibbs records the results of some considerations relative to a science, called "Statistical Mechanics," the laws of which will govern the behaviour of a great number of analogous systems independent of one another as to their motion. These laws being, however, limited to systems made up of ponderable matter, the author here endeavours to apply similar considerations to electromagnetic systems, with a view to obtaining a means of completing our knowledge of the radiation phenomena from a thermodynamic point of view. After discussing the very limited value of Gibbs' "canonic systems," the author goes on to show that the so-called "law of conservation of phase density" is valid in the case of electromagnetic systems as well. As the motion of canonic systems cannot be applied to ethereal

systems, a similar mode of distribution, termed quasi-canonical distribution, is considered, and it is shown that this affords a means of determining the distribution of energy over the different times of vibration. As, however, the state of a space filled up with "black" radiation is not represented by the equations derived, it proves impossible to deduce, on Wien's law of displacement, a complete spectral formula for "black" radiation. A. G.

2239. *Unipolar Induction.* **E. Hoppe.** (Ann. d. Physik, 8. 3. pp. 663–674, June, 1902.)—The author describes a method used by him for observing the so-called unipolar induction. The conductor under observation contained in its circuit the primary of a secondary with a soft iron core, the "unipolar" induction current in the conductor being thus detected by a second induced current. He finds that no current is induced in a conductor rotating in rigid connection with a magnet, and hence that no electrostatic charge is produced on such a conductor. It follows that the rotation of the earth regarded as a magnet can produce no electric charge on the earth's surface. W. S.

2240. *Condensers.* **A. Garbasso.** (Elettricista, Rome, 11. pp. 143–146, June, 1902. Phys. Zeitschr. 3. pp. 384–385, June 1, 1902.)—A condenser of capacity C, outer plate to earth, is charged with quantity q; the charged plate is put to earth through two wires R_1L_1 and R_2L_2, and the currents are i_1 and i_2. Mathematical treatment of the fundamental equations shows that the charge in the condenser and the currents in the wires present an oscillating and a continuous term. Under certain conditions, when one of the wires is much more resistent than the other, the continuous current passes in it by preference. When $R_1/L_1 = R_2/L_2$, the discharge takes place as if through a single wire in which $R = R_1R_2/\overline{R_1 + R_2}$ and $L = L_1L_2/\overline{L_1 + L_2}$. A. D.

DISCHARGE AND OSCILLATIONS.

2241. *Dispersion of Electricity in the Air.* **W. W. Schiptschinsky.** (Jurn. Russk. Fisik. Chimicesk. Obščestva, 34. 3b. pp. 47–49, 1902.)—The author points out the necessity of taking due account of the differences of apparatus, when comparing the results obtained by W. Loevy on the dispersion of electricity in the air [see Abstract No. 702 (1902)], with the outcome of Elster and Geitel's work in the same line. Many seeming divergences may thus be interpreted. A. G.

2242. *Velocity of Ions from Hot Platinum Wires.* **C. D. Child.** (Phys. Rev. 14. pp. 221–246, April, and pp. 265–279, May–June, 1902.)—This paper deals principally with the discharge from a hot platinum wire in other gases than air, and in a vacuum. There are present about the wire, particles which diminish the velocity of the ions, and these particles come from the hot platinum, not from the copper connections. They have a greater retarding action on the negative ions drawn from a flame than on the positive. In hydrogen the rate of discharge is much larger than in air. The positive discharge begins at lower temperatures than the negative, but is soon surpassed by the negative, which passes through a maximum and rapidly decreases, coming to have nearly the same value as the positive when very near the melting-point. The behaviour of the wire in oxygen, CO_2 and CO is practically the same as in air. The experiments seem to show that the particles are driven off as platinum, not as some oxide of platinum. When a platinum wire is first heated

in a vacuum, the rate of discharge is much greater than at any time afterwards. Heating the wire in hydrogen, to some extent restores to it the power of producing a large discharge, but no effect was thus produced on the negative discharge. The rate of discharge in a vacuum is much greater than in air at atmospheric pressures. The amount of both positive and negative discharges continually increases as the temperature of the wire is increased. The potential difference between the wire and cylinder about it has little effect on the amount of discharge in a vacuum, and in this respect it behaves differently from the wire in air at atmospheric pressures. No method was found by which the velocity of the ions in a vacuum could be determined. The phenomena observed indicate that the ionisation first occurs within the wire, and there are reasons for thinking that this part of the ionisation is produced from occluded hydrogen. W. C. H.

2243. *Electric Conductivity of Air.* **A. Pochettino** and **A. Sella.** (Accad. Lincei, Atti, 11. pp. 527–531, June 15, 1902.)—Air churned up with water (not simply bubbled through) acted in discharging a conductor as if it had picked up some radio-active substance from the water (Marcia, Rome water-supply). A. D.

2244. *Conductivity in Gases under Ultra-Violet Light.* **J. S. Townsend.** (Phil. Mag. 3. pp. 557–576, June, 1902.)—The author has repeated, with various modifications, the experiments of Stoletow, on the currents produced in gases by ultra-violet light falling on a metallic surface in the gas. The ratio of the conductivities of the gas between two plates, on one of which the light falls, can be calculated according to the author's theory [see Abstracts Nos. 1347 and 1351 (1902)], and this is compared with the value found experimentally. The results confirm the author's theory, and they also show that the increase in current observed when the plates are further separated may be explained in the same manner. R. S. W.

2245. *Sparking Potential.* **E. Warburg.** (International Physical Congress at Paris, Report, 4. pp. 117–118, 1900–1901.)—When the difference of potential between the electrodes is slowly raised there is, in ordinary air, a retardation of the discharge, which makes the measurement of the corresponding potential very difficult; but if the electrodes be exposed to ultra-violet, to Röntgen or to Becquerel rays, the appearance of the discharge occurs at a very precisely measurable potential, which is not always less with than it is without such rays. The author considers the value obtained under the influence of these rays to be the true value of the required potential-difference. When the difference of potential is suddenly raised the phenomenon becomes more complicated. [See also Abstract No. 382 (1901).] A. D.

2246. *Chemical Change and Electrical Conduction in Gases; Luminosity.* **H. E. Armstrong.** (Roy. Soc., Proc. 70. pp. 99–109, May 31, 1902.)—The author regards the recent work of Brereton Baker—who has shown that even the most vigorous chemical reactions do not take place in absence of all traces of moisture—as confirming his own view that the presence of an electrolyte is a necessary condition for chemical action to take place, and that pure gases should be perfect dielectrics. The question of electrical discharge in gases has not, as yet, been subjected to the same accurate methods as have been employed by Dixon, Baker, and Shenstone in their investigations of

chemical change, but the author brings forward evidence in favour of the view that the discharge in a vacuum tube is occasioned by the presence of minute quantities of impurities derived from the soft glass from which the tubes are constructed and from the sulphuric acid and commercial phosphorus pentoxide employed in drying the gases. The luminosity of the rare earths, the incandescence of oxides generally, and the phosphorescent phenomena produced by the action of the electric discharge may all be processes of oscillatory or recurrent oxidation or polymerisation. The author holds similar views with regard to the emanations from radio-active materials and to the ionisation of air. T. H. P.

2247. *Effect of Self-Induction of a Coil in the Ultra-violet Part of the Spark Spectrum.* **E. Néculcéa.** (Comptes Rendus, 134. pp. 1494–1496, June 23, and pp. 1572–1575, June 30, 1902.)—The self-induction of the coil used ranged from 0·000602 to 0·04191 henrys, according to the number of layers used; and the spectra of the following metals were investigated: Cadmium, zinc, lead, bismuth, antimony, iron, nickel, cobalt, &c. Taking lead as an example, the authors examine the region $\lambda = 2700$ to $\lambda = 2000$, and find for twenty-two different wave-lengths the effect of the variation of self-induction. Of these only nine remain in the extreme ultra-violet, when the self-induction rises to 0·0491. A description of the optical system for obtaining the spectrograph is given. J. W. P.

2248. *Effect of Moisture upon Discharge between the Knobs of a Ruhmkorff Coil.* **H. Bordier.** (Comptes Rendus, 134. pp. 1493–1494, June 23, 1902.)—The effect of a deposit of moisture upon the knobs is to increase the ease of the spark discharge. An apparatus is described by which the knob connected to the kathode may have moisture produced on it at will, and the temperature of this may be measured. After separating the knobs so that the sparks cease to pass, the temperature of the kathode is gradually lowered, and is read at the moment of starting of the sparks and at the moment of appearance of the moisture. The phenomenon might be used for determining the saturation temperature. J. W. P.

2249. *Influence of Röntgen Rays on very small Sparks.* **R. Blondlot.** (Comptes Rendus, 134. pp. 1559–1560, June 30, 1902.)—A small spark is caused to play between the pointed ends of a copper wire in such conditions that the voltage used is just sufficient to maintain the discharge. When Röntgen rays are allowed to fall on the gap the spark becomes whiter and much more intense. This is because the rays increase the gas conductivity, and so more current passes. A large spark-gap does not show this effect because the heating and ionising power of the spark itself is so much greater as to make it unnoticeable. R. S. W.

2250. *Velocity of Ions in Flames containing Salts.* **G. Moreau.** (Comptes Rendus, 134. pp. 1575–1577, June 30, 1902.)—Two exactly similar flames come in contact with each other at about half their height. One contains vapours of the salt under experiment. A platinum electrode is placed in each flame, and the current passing from one to the other is measured for known potential differences. From these observations and a measurement of the velocity of the gas in the flame the velocity of the ions is calculated. The results are given for negative ions only, for various salts of potassium and sodium. They

show that the velocity for a given concentration is independent of the anion, that it diminishes rapidly as the concentration increases, and for small concentrations tends to the same limiting value for the salts of potassium and sodium. R. S. W.

2251. *The Electric Discharge in Rarefied Gases.* **W. Wien.** (Ann. d. Physik, 8. 2. pp. 244–266, May, 1902. Also Electrician, July 18 and 25, 1902.)—The author begins by explaining the precautions necessary to obtain magnetic and electrostatic deflection of the canal rays, and goes on to describe experimental results. In the highest vacua obtainable there are no canal rays, but kathode rays can be detected, due, not to a gaseous residue, but to the metals of the electrodes. At the highest vacua the passage of the current is altered quantitatively but not qualitatively by using incandescent electrodes such as platinum or carbon filament. The author next describes the fluorescence produced by the canal rays when the tubes contain different gases. He then discusses the electrostatic deviation of the canal rays, and describes the changes in the fluorescence when they are accelerated by electrostatic force. Finally he gives his results for change of fluorescence, and for deviation under the combined influence of magnetic and electrostatic force, giving the value of the ratio e/m for the most deviable rays in various gases. He concludes with certainty that the small deviation of a part of the canal rays is due to alteration of the ratio of charge to mass along the path of such rays, and that some, if not all, of the canal-ray group are due to the gaseous contents of the tube. The canal rays are being continually reconverted into neutral gas, a cyclic process thus going on during the discharge. W. S.

2252. *The Canal-Ray Group.* **E. Goldstein.** (Deutsch. Phys. Gesell., Verh. 4. 10. pp. 228–244, May 30, 1902.)—One may speak of a canal-ray group, inasmuch as several kinds of ray exist which have some properties in common with the canal rays proper, though at the same time they differ in other respects. The author considers that hitherto insufficient attention has been paid to the part played by the apertures used in the kathode, and describes phenomena observed with various forms of opening. He concludes from his experiments that at least five different members of the canal-ray group can be distinguished, which are as follows: I. The first layer of the kathode light. It has been supposed that the canal rays are identical with those, being merely rays of the first layer which have passed unchanged through the openings in the kathode. This supposition has been disproved by Goldstein [see Abstract No. 1900 (1902)], who has shown that the rays of the first layer are very sensitive to influences which scarcely affect the true canal rays. II. The true canal rays, which issue in straight lines from the openings in the kathode, and from the side turned away from the anode; they cannot be sensibly deflected by small magnetic or electrostatic forces. III. Those rays which emanate from kathodes with or without openings, and proceed towards the anode from the side next it; they may be observed when the ordinary kathode rays are deflected to one side by a magnetic field, and are no more sensitive to electric and magnetic forces than are the true canal rays. IV. *Regular* cloudy rays which envelop the true canal rays. V. *Diffuse* cloudy rays which seem to bear to the regular cloudy rays and the true canal rays the same relation which the light of the third kathode layer bears to the ordinary regular kathode rays; that is, they seem to be produced by the true canal rays striking the gaseous particles. W. S.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

2253. *Dielectrics at Low Temperatures.* **J. Curie** and **P. Compan.** (Comptes Rendus, 134. pp. 1295–1297, June 2, 1902.)—The authors have investigated the specific inductive powers of different solid dielectrics at low temperatures, the arrangement being as described by J. Curie in Ann. de Chim. et de Phys., 1889. The present paper refers only to tests upon glass. Three specimens of microscope (crown) glass were used, and were found to give analogous results; but certain differences in the same specimen are to be observed, depending upon the duration of the successive temperature conditions, the time-interval of charge, and upon whether the temperature is varied by successive increments of heating or of cooling. In the following table the specific inductive powers at different temperatures C. are set forth for different times of charge. The letter *d* placed at the side of a number indicates that the value is obtained for descending temperatures, and the letter *r* represents a cycle of rising temperatures.

Duration of Charge, in Seconds.	Temperature C.				
	+ 13°	0°	− 19°	− 75°	− 185°
10	11·25	9·47	8·44	7·09	6·49
1	9·32	8·44	7·81	7·09	6·49
0·1	8·04*d* 7·75*r*	7·75*d* 7·52*r*	7·42	7·09	6·49
0·05	7·85*d* 7·59*r*	7·50*d* 7·42*r*	7·36	7·09	6·49

So far as these tests go, they appear to indicate that at temperatures lower than − 75° C. the inductive power of glass is independent of the duration of charge between the limits 0·05 seconds and 10 seconds. For short charges the inductive power of glass varies only slightly with temperature. The inductive power of glass increases with temperature according to a law of the form $k = k_0 + AT$, where k_0 is a constant which should be the inductive power at absolute zero, and where T is the temperature on the absolute scale. A is a constant characteristic of the substance. For the three specimens of glass examined the values of k_0 and A were found to be as follows:—

Specimen No.	k_0	A
1	6·03	0·00524
2	6·83	0·00520
3	6·24	0·00533

Analogous results have been found for ebonite, mica, and quartz, and a similar linear law is said to hold for them. R. A.

2254. *Dielectric Constant of Glass by Electric Waves.* **J. A. Pollock** and **O. U. Vonwiller.** (Phil. Mag. 3. pp. 586–606, June, 1902.)—In this investigation electric waves were generated by the discharge of a condenser whose

dielectric was at pleasure glass or air of an equivalent thickness. This thick
ness of air was ascertained by observations of waves induced on a shor
system of parallel wires with or without bridges. All the specimens of glas
used were "thick polished plate glass" from Floreffe, Belgium. Th
dielectric constant under alternating electric forces with a frequency o
twenty million per second was found to be 7·87 at 26° C., whereas tha
found by an absolute electrometer method for alternations of 50 per secon
at 25·5° C. was 7·79, or practically the same. E. H. B

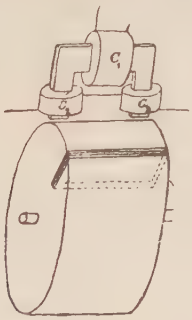
2255. *Conductors of the Second Class.* **A. Kiesewalter.** (Schweizerisch
Blätter für Elektrotechnik, 7. pp. 49–51, April 8, 1902.)—The development of th
Nernst lamp and the employment of so-called conductors of the second class
have led the author to investigate the latter. Two classes of these conductor
are important. Class 1. Earths and earthy metals combined with fixed acids
such as, for instance, alumina, generally in combination with SiO_2. Class 2
Alkaline earths combined with volatile acids, such as lime, magnesia, baryt
combined with CO_2, and HF. The infusibility of alumina combined wit
alumina silicates, decreases with the increase of SiO_2, and also Fe, alkalis, C
and Mg, until it will not stand more than 800° C. without melting, whereas
true mono-silicate is not affected up to 1,840°, and even more. The tw
methods employed by Bishop and Segner for gauging the melting-point o
such bodies are compared, preference being given to the latter, as it entail
the employment of fusible cones (590° C. to 1,840° C.). The following result
were obtained : Clay (alumina with 30 per cent. silica) was melted at a tem
perature of a No. 30 cone, using rods of 6 mm. diameter and 25 mm. long, th
operation being carried out in a Deville furnace. A similar rod, after heatin
in a Bunsen flame, readily melted at an e.m.f. of 120 volts. By using 25 volt
only, the rod could be made to grow luminous. After cooling, the rod wa
found to be in a spongy condition. According to the author, this is due t
the presence of 1½ per cent. of soda. Classes 1 and 2 gave similar result
The more refractory the substance the less time was required to render th
substance conductive by means of the Bunsen flame. Further experimen
proved that the presence of alkalis had a detrimental effect upon the condu
tivity, and they must therefore be avoided. Materials heated in a magnes
crucible to about 2,000° C. in a Deville furnace became luminous on passin
a current of 50 to 80 volts, the luminosity being controlled at will by alterin
the e.m.f. The author states that the emission of light is the result of wav
produced by the current, and not by the effect of heat only, as a No. 3
Segner cone heated to 1,840° C. did not give off any considerable quantity
light. For the purpose of producing electric light by conductors of th
second class, only such alkaline earths are of use, the melting of which
beyond the temperature produced by an e.m.f. customary for the purpose
electric lighting. The following oxides are suitable for this purpose : Chem
cally pure oxides of silicon, magnesium, barium, calcium, aluminium, an
Zirconium. The melting-points of these bodies lie between 2,000° an
2,500° C. They should be used by themselves and not mixed together,
this causes a considerable drop in their melting-points. Finally, the auth
draws attention to the fact that these bodies volatilise, and in some cas
sinter together, and thereby occasionally crack. He again draws attention
the fact that the more refractory the bodies the less time is required to rend
them conductive. A third group of bodies which the author is experimenti
with, and which will form the subject of a future communication, do n
require preliminary heating, at the same time being sufficiently refractory.
O. J.

2256. *Simple Radio-conductors.* **F. Piola.** (Elettricista, Rome, 11. pp. 137–141, June, 1902.)—The resistance assumed by a radio-conductor (two steel bicycle balls in petroleum) originally not conducting, is approximately inversely proportional to the quantity of electricity which is discharged on to them when such discharge is produced by condensers of sufficiently small capacity. A. D.

2257. *Mercury Current-Interrupter.* **W. A. Del Mar.** (Amer. Electn. 14. pp. 295–297, June, 1902.)—One end of the iron core of the induction coil is filed away at a slant of 45° with the horizon. The moving armature is a small portion of a cylinder of iron co-axial with the core and filed to a corresponding slant; it is supported by a horizontal straight spring, fixed so that the two slant faces are brought near to one another. The armature is thus able to move up and down with respect to the core. A vertical iron rod attached to the armature dips into a mercury cup, and contact is made and broken in the usual way. It is claimed that this arrangement enables adjustments to be easily made. R. A.

ALTERNATING CURRENTS AND MAGNETISM.

2258. *New Wave-Form Apparatus.* **R. Goldschmidt.** (Elektrotechn. Zeitschr. 23. pp. 496–497, June 5, 1902.)—The construction of the apparatus will be understood from the accompanying diagram, in which C_1 is the primary, and C_2 the secondary coil of a small transformer having a ⊓-shaped core. The primary coil is connected to the source of alternating e.m.f., or is introduced into the circuit in which the current-wave is to be determined. The secondary coil is joined in series with a suitable alternate-current voltmeter and the secondary coil of another small "compensating" transformer



(closed magnetic circuit), the e.m.f.'s in the secondaries opposing each other so that the changes of induction due to the p.d. or current-wave in C_1 are without effect on the voltmeter. Close to the projecting ends of the ⊓-shaped core is rotated (synchronously) a drum, into which are let a few thin strips of soft sheet-iron; these form the movable yoke of the core, and it is evident that every time this yoke passes the core a very sudden increase and decrease in the magnetic flux will take place, and the voltmeter will give a reading proportional to the instantaneous value of the current in C_1. The small transformer is mounted on an arm capable of rotation about the axis of the drum, and may be clamped in various positions, corresponding to different values of the instantaneous p.d. or current. The method of using the appa-

ratus is precisely similar to that employed with a Joubert contact-disc, but it possesses the great advantage of doing away with the difficulty due to uncertainty of contact. Samples of curves obtained with this form of apparatus are given by the author. A. H.

2259. *Heating of Non-Magnetic Rods by Foucault Currents.* **W. Ignatowsky.** (Jurn. Russk. Fisik. Chimičesk. Obščestva, 34. 3b. pp. 49–61, 1902.)—The author gives the mathematical theory of the following laboratory experiment: An alternate current being made to traverse an induction coil containing a copper rod, the quantity $W = CE \cos\phi$ is found by means of a wattmeter. C and E are subsequently derived from the readings of a voltmeter and an ammeter, $\cos\phi = W/CE$ being thus determined. Now $W = C^2R + W_1$, where C^2R is the energy corresponding to the Joule heat evolved in the circuit, and W_1 the energy lost by the Foucault currents in the rod. Taking out the rod, the wattmeter will give $W_0 = C^2R$, and therefore $W_1 = W - W_0$. The theoretical deductions given in this paper fully warrant this method of measuring W_1. A. G.

2260. *Magnetic Constants of Iron.* **D. Mazzotto.** (N. Cimento, 3. pp. 417–442, June, 1902. Bologna Congress of the Soc. Ital. di Fisica, Sept. 27, 1901.)—If iron be heated to a red heat and then exposed for a long time to a uniform temperature far below a red heat, its magnetic constants vary slowly towards a stable limiting value which depends upon that temperature; the susceptivity and permeability diminish, while the residual magnetism, the coercitive force, and the field of maximum susceptivity increase; and these changes are more marked but slower in manifesting themselves the lower the temperature (down to 100°) at which the iron is maintained. The difference between red-hot iron and long-tempered iron in respect of the susceptivity in equal fields, which is most marked in feeble fields, diminishes as we pass from the field of maximum susceptivity to stronger fields, and in strong fields it vanishes. The ratio between the residual magnetism in the two cases is the same whether the field be strong or weak. The changes are most marked and appear most promptly in "best" iron, next in Swedish, least so in steel. Long exposure to a given temperature does not render iron immune from other changes at other temperatures; the magnetic constants tend to reach the limiting values corresponding to the new temperatures. Since protracted exposure to a given temperature does not alter the susceptivity in strong fields, it appears that the increase in hysteresis losses in alternating current machines is due, not to diminutions in the permeability, but to increases in the permanent magnetism and the coercitive force of the cores. A. D.

2261. *Magnetism of Compounds of Iron and Silicon.* **A. Jouve.** (Comptes Rendus, 134. pp. 1577–1579, June 30, 1902.)—The attractive power of an electromagnet on a constant mass of the material is measured for different percentages of silicon. To do this the alloy is powdered and put in a small box. Brusque changes are noticed when the silicon is 20 per cent. and 33 per cent. of the mixture. Definite compounds of iron and silicon, Fe_2Si and FeSi, are hence inferred. R. S. W.

2262. *Magnetic Properties of Alloys of Nickel.* **B. Hill.** (Deutsch. Phys. Gesell., Verh. 4. 9. pp. 194–203, May 9, 1902.)—Following his research on other alloys, the author investigates the effect of increasing the amount of

alloying metal, copper or zinc, on the properties of nickel. In the case of the copper alloys he takes 4, 8, 20, and 40 per cent. of copper; placing one rod of the alloy at a time wound with (1) primary coil, (2) secondary coil, and (3) heating coil, he finds the change in magnetic intensity as temperature changes. He takes van't Hoff's formula, $\Delta t = 0{\cdot}02mT^2/ML$, which applies to the lowering in freezing-point (Δt) as m grams of salt are dissolved in 100 of solvent, M being the molecular weight of the salt, T absolute temperature, and L the latent heat of the change of state. Apply this to the change in the transformation temperature of the alloys. According as more or less (m) alloy is introduced he finds the expression holds good with considerable accuracy. In the case of the tin alloys the percentages of tin are 5, 10, 15. Here again the formula applies well. Thus the ratio $\Delta t/m$ gives values 7·4, 7·2, 7·3 for the three alloys. P. E. S.

2263. *Magnetic Disturbances during the Mont Pelée Eruption.* **L. A. Bauer.** (Terrestrial Magnetism, 7. pp. 57–58, June, 1902.)—Magnetic disturbances occurred at the observatories of Cheltenham, Maryland, and Baldwin, Kansas, simultaneously with the eruption of Mount Pelée on May 8, and the reports from Toronto, Honolulu, Stonyhurst, Val Joyeux, Potsdam, and Pola, show that the disturbance was general. Strikingly similar records were obtained in the preceding weeks, and again on May 20; the Guatemala earthquake of May 18 also seems to have given rise to magnetic disturbances. The magnetograms of May 7–8, obtained at Cheltenham with the Adie magnetograph, are reproduced. H. B.

2264. *Magnetic Survey of Central Madagascar.* **Colin.** (Comptes Rendus, 134. pp. 1274–1278, June 2; and pp. 1339–1341, June 9, 1902.)—The Ankaratra Plateau of Central Madagascar is distinctly of volcanic origin though active volcanoes are unknown. The author has determined the magnetic elements at thirty-five stations, and observed many remarkable anomalies; the direct influence of the volcanic zones appears, however, to be local. The first paper tabulates the observations, the second paper contains comments. H. B.

REFERENCES.

2265. *Decimal Unit of Time.* **J. de Rey-Pailhade.** (International Physical Congress at Paris, Report, 4. pp. 65–68, 1900–1901.) [See Abstract No. 724 (1902).] A. D.

2266. *The Electronic Theory of Electricity.* **J. A. Fleming.** (Popular Science, Monthly, 61. No. 1, pp. 5–24, 1902.)—The paper contains a general sketch of the history and present position of the theory. G. W. DE T.

2267. *Reflexion of Kathode Rays.* **H. Starke.** (Deutsch. Phys. Gesell., Verh. 4. 9. pp. 212–224, May 9, 1902.)—The paper criticises the results obtained by Austin and Starke on the reflexion of kathode rays. Further examination, according to the author, only serves to confirm the results he and Austin obtained. [See Abstract No. 2077 (1902).] R. S. W.

2268. *Reflexion of Kathode Rays.* **J. Stark.** (Phys. Zeitschr. 3. pp. 368–373, May 15, 1902.)—A paper in support of the author's theory as opposed to the results of Austin and Starke. [See preceding Abstract.] R. S. W.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

2269. *Weight and Chemical Transformation.* **Rayleigh.** (Nature, 66. pp. 58–59, May 15, 1902.)—The author refers to the inference drawn by Heydweiller [see Abstract No. 1760 (1901)] from some of his experiments, that certain chemical transformations are attended by minute changes of weight. He then argues from thermodynamical considerations that such changes in weight are inadmissible, except on the hypothesis that hitherto unsuspected thermal effects accompany a rising or falling against or with gravity. G. W. DE T.

2270. *Polymorphism and Chemical Isomerism.* **G. Bruni.** (Accad. Lincei, Atti, 11. pp. 386–389, May 4, 1902.)—This is a continuation of the author's essays on the properties of mixtures of isomeric bodies [see Abstracts Nos. 485 and 1402 (1899) and 539 (1900)], dealing in this case chiefly with the points of congelation. He agrees with Wegscheider (Wiener Monats. f. Chem. cxxii. 917, 1901) as to the propriety and convenience of a distinction between polymorphs and isomers, and points out that "of two polymorphous bodies, one only has a stable fusion-point; the point of fusion of the other corresponds to a state of unstable equilibrium which the smallest trace of the first modification can cause to disappear. On the other hand, two isomeric bodies have each a stable fusion-point in the sense of the theory of phases." S. R.

2271. *Atomic Weight of Calcium, II.* **F. W. Hinrichsen.** (Zeitschr. Phys. Chem. 40. pp. 746–749, May 20, 1902.)—By heating pure native calcite the author had obtained the number 40·142 (O = 16) [see Abstract No. 731 (1902)]. He has repeated his determinations on a very pure calcite from the Crimea, in which the traces of impurities were carefully determined and allowed for. The heating was effected in an electric oven at 1,200–1,400°, and gave the values 40·139 and 40·136. S. R.

2272. *Classification of the Elements.* **H. E. Armstrong.** (Roy. Soc., Proc. 70. pp. 86–94, May 31, 1902.)—This is an arrangement in sixteen columns, taking the "elementary difference" as about a single unit; so that the elements are entered under whole numbers, neglecting the exact atomic weights; the first horizontal period comes to an end with oxygen. Several new groupings result similarly to the familiar ones of the iron and platinum metals. Tellurium is placed before iodine, with an atomic weight of 124. S. R.

2273. *Suggested Modifications of the Sign of Equality for Use in Chemical Notation.* **H. Marshall.** (Roy. Soc. Edinburgh, Proc. 24. pp. 85–87, May, 1902.)—The sign with opposite arrows now employed for reversible equations is the same as that often used in organic chemistry to indicate that each of the two substances concerned may serve as starting-point for the preparation of the other. The author suggests a pair of singly barbed arrows as a better means of representing reversible reactions, and advocates the adoption of such a sign for all complete chemical questions. For irreversible actions the sign would be $\Longrightarrow$, for reversible actions $\rightleftharpoons$, while for reversible action

associated with a definite transition temperature he suggests $\rightleftharpoons$ with a figure above giving the temperature involved. When the action under ordinary conditions goes almost wholly in one direction, or there is doubt as to its reversibility, the sign $\rightleftharpoons$ is proposed. S. R.

2274. *Molecular Complexity of Acetic Acid in Chloroform Solution.* **H. M. Dawson.** (Chem. Soc., Journ. 81. and 82. pp. 521–524, May, 1902.)—From previous experiments [see Abstract No. 2294 (1902)] it had been found that the distribution-ratio of acetic acid between water and chloroform varies very considerably with the concentration. On the assumption that this is due to the existence of dissociating double acetic acid molecules in the chloroform, the dissociation-isotherm in the chloroform solution can be readily written down. This equation involves two unknowns, r the distribution ratio of the simple molecules and K the dissociation-constant. Two experiments serve to determine r by elimination of K, and from this value of r values of K can then be calculated from the data of the remaining experiments. The values of K so obtained remain practically constant while the concentration of the acetic acid in the chloroform undergoes a change in the ratio of 1 to 40.

F. G. D.

2275. *Double-Salts of Magnesium and Zinc Sulphates.* **R. Hollmann.** (Zeitschr. Phys. Chem. 40. pp. 577–580, May 13, 1902.)—It has already been shown [see Abstract No. 1737 (1901)] from the vapour-tension curve of mixed crystals of $ZnSO_4 . 7H_2O$ and $MgSO_4 . 7H_2O$ that these two salts form double salts $MgZn(SO_4)_2 . 14H_2O$ and $Mg_2Zn(SO_4)_2 . 21H_2O$ which are isomorphous with each other and with their constituents. Similar results have now been obtained by studying the temperature at which the crystals decompose into the hexahydrated form. This temperature, which is at 48·5° in the case of pure $ZnSO_4 . 7H_2O$, falls to a minimum at 44·4° when the crystals have the composition $ZnMg_2(SO_4)_3 . 21H_2O$, rises to a maximum at 44·9° and falls to a second minimum at 43·1°, when the crystals have the composition $ZnMg(SO_4)_2 . 14H_2O$, and after rising to a second maximum falls to 38·7° in the case of pure $MgSO_4 . 7H_2O$. T. M. L.

2276. *Calculation of Solubilities and Equilibrium Constants. Formula for Latent Heats of Vaporisation.* **A. Findlay.** (Roy. Soc., Proc. 69. pp. 471–478, April 4, 1902.)—The theory of corresponding states, which was used by Ramsay and Young to calculate the vapour pressure of one liquid from that of another by determining the ratio at two temperatures only, is now applied to the calculation of solubilities. In the equation $R = R' + c(t' - t)$, c is a constant, and R R′ are the ratios of the absolute temperatures at which the two substances have equal solubilities, and t' and t are the actual temperatures for one of the substances. Thus $ZnBr_2$ and $ZnCl_2, H_2O$ have equal solubilities at 313·0° and 283·9° (abs.) and again at 338·0° and 286·2° (abs.); from these values c is calculated to be 0·00316. The temperature at which zinc chloride has a given solubility can then be calculated if the corresponding temperature for zinc bromide be known. The maximum error in seven observations was 0·7° C. Tables are also given for KBr, and KCl, KNO_3 and $CdBr_2, 4H_2O$, and m and p hydroxybenzoic acids. A similar method is applied to the equilibrium constants of the equations $2HI \rightleftharpoons H_2 + I_2$ and $2CH_3 . CO . CH_3 \rightleftharpoons CH_3 . CO . CH_2 . C(CH_3)_2 . OH$. For calculating the latent heat of vaporisation the formula $L_1 = L_2 T_2^x$ is given, where L_1 is the latent heat of a standard substance

at temperature T_1, T_2 is the temperature at which the second substance has the same vapour pressure as the standard at temperature T_1, x is a constant, and L_2 is the required latent heat of the second substance at temperature T_2.

T. M. L.

2277. *Solutions of Gases in Liquids.* **J. A. Wanklyn.** (Phil. Mag. 3. pp. 346–348, March, and pp. 498–500, May, 1902).—Carbon dioxide is capable of being absorbed by water without any shaking, the absorption being at the rate of about 0·375 c.c. per hour for each sq. cm. of surface. If, however, carbon dioxide be placed over its saturated solution, and strong potash is carefully placed below the aqueous layer, the volume of gas remains constant during 48 hours, but vanishes in a few minutes when the contents of the tube are shaken. This result serves to show that the rate of diffusion of carbon dioxide in aqueous solution is exceedingly slow. The author considers that the experiment establishes the fact that the single molecules of CO_2 are attached to many molecules of H_2O, forming large compound molecules. The absorption of CO_2 by pure water, which proceeds much more rapidly, may be accounted for by the density of the CO_2 solution, which is greater than that of water and would tend to set up convection currents. Similar experiments were made with ammonia, the column of gas (38·2 c.c.) being separated from a column of water (5·5 c.c.) by means of a column of saturated solution (7·5 c.c.). When the experiment was set up the volume of gas was 34·8 c.c., which decreased after three hours to 23·1 c.c., after ten hours to 7·13 c.c., and disappeared instantly on slight shaking. In this case, therefore, the gas diffuses only with great slowness, and it is suggested that in the purification of water a layer of still water 4 in. thick would protect organic matter from the oxidising action of the atmosphere for more than a month.

T. M. L.

2278. *Slow Oxidation of Methane at Low Temperatures.* **W. A. Bone** and **R. V. Wheeler.** (Chem. Soc., Journ. 81. and 82. pp. 535–549, May, 1902.)—Mixtures of methane and oxygen, sealed, at atmospheric pressure, in cylindrical bulbs of boro-silicate glass with capillary ends, were maintained for several days at 300–400°, then opened under mercury, and the gas analysed. It was found that at these temperatures combination ensues with an enormously greater velocity than it does between hydrogen and oxygen. The sole products obtained were water, CO and CO_2; free H or C was not detected at any stage. Figures are given of apparatus for the preparation of the gas and manipulation of the bulbs. The experiments are being extended to other hydrocarbons.

S. R.

2279. *Diffusion of Hydrogen through Platinum.* **A. Winkelmann.** (Ann. d. Physik, 8. 2. pp. 388–404, May, 1902.)—The author describes the methods and apparatus employed in his investigations, and from the results obtained the following conclusions are drawn : (1) The diffusion of hydrogen through glowing platinum does not proceed proportionally to the pressure of the gas. (2) This diffusion is most probably accompanied by a dissociation of the hydrogen molecule, so that only the atoms, and not the molecules, of the gas pass through the platinum. Assuming that such dissociation occurs, the author applies the mass laws to the derivation of a formula for the constant of diffusion. [See also Abstract No. 2195 (1901).]

T. H. P.

2280. *Extension of the Concept of Critical Quantities.* **A. Batschinski.** (Zeitschr. Phys. Chem. 40. pp. 629–634, May 13, 1902.)—Designating substances for which the molecule of the liquid is similar to that of the saturated vapour as orthomeric, and others as allomeric, the author suggests that an orthomeric polymerised substance may be brought under the law of corresponding states by substituting, for the critical constants, determinate functions of the pressure and temperature, which he calls metacritical, and which at the critical point become identical with the critical constants. A physical interpretation might be given to these functions, if, for example, it were a realisable process to bring a substance from a given condition into the state in which there is no difference between the fluid and its vapour, without allowing any change to occur in its polymerisation ; the final temperature and pressure would be the corresponding values of the metacritical functions. A method is explained, and applied to the case of acetic acid, of determining the values of these functions when the specific volumes of an orthomeric substance in the fluid and vapour states are known for different boiling-points and different pressures, or the theory of the viscosity of liquids might be used for the same purpose. W. E. T.

2281. *Synthetic Analysis in Ternary Systems.* **A. W. Browne.** (Journ. Phys. Chem. 6. pp. 287–312, May, 1902.)—The results are given of experimental applications of the method suggested by Bancroft [see Abstract No. 1915 (1902)] for analysing the solid phase appearing in three component systems without removing it from the mother-liquor. Of the many possibilities regarding the composition of the solid phase, three cases are illustrated by the experiments, viz., where it is (1) a pure component, by the system potassium chloride, hydrochloric acid and water ; (2) a binary compound of components, by the systems (*a*) sodium sulphate, sodium chloride and water, (*b*) barium chloride, hydrochloric acid and water, (*c*) ferric chloride, hydrochloric acid and water ; (3) a binary solid solution, by the system potassium sulphate, ammonium sulphate and water. Both the direct and zero methods are employed, and the utility of the triangular diagram for assigning the limits of error is explained. The author suggests that with special precautions the method might be applied to the determination of the atomic weights of certain elements. W. E. T.

2282. *Indifferent Points.* **P. Saurel.** (Journ. Phys. Chem. 6. pp. 313–320, May, 1902.)—According to Duhem, an indifferent point is such that, at the corresponding temperature and pressure, a reversible change is possible in which the masses of the phases vary while their concentrations remain unchanged. The author has previously obtained in a general analytical form the necessary and sufficient conditions which must hold at such an indifferent point [see Abstract No. 937 (1901)]. The present paper is concerned with the same question as viewed from a geometrical point of view. The result is as follows : In order that a multivariant system of r phases may be at an indifferent point, it is necessary and sufficient that the representative point of the system and the representative points of the r phases lie in the same flat space of $r-2$ dimensions. F. G. D.

2283. *Equilibria in Systems of Three Components in which Two Liquid Phases can occur.* **P. A. Meerburg.** (Zeitschr. Phys. Chem. 40. pp. 641–688, May 20, 1902. Abstract of author's dissertation, "Influence of a Third Substance on the Equilibrium in the System Triethylamine–Water," Leyden,

1900.)—In this paper, which is a continuation of Schreinemaker's work, three component systems are studied in which two of the components taken alone exhibit a so-called lower critical mixing temperature, *i.e.*, these two components are such that they form at lower temperatures a homogeneous liquid phase which at higher temperatures breaks up into two liquid phases. The systems studied contain triethylamine and water in every case, as these are the two components exhibiting the above phenomenon. The third component chosen is either ethyl alcohol, diethyl ether or phenol. For details of the work, which is a phase-law study of the various equilibria, reference must be made to the original. F. G. D.

2284. *Velocity of Combination of Heterocyclic Compounds with Bromhydrine.* **N. Menschutkin.** (Jurn. Russk. Fisik. Chimičesk. Obščestva, 34. 4a. pp. 411–422, 1902.)—The author shows that in all cases tested, with open as well as with closed chains, the influence of a lateral chain upon the velocity of reaction is manifested in the same sense, viz., as a delay. This uniformity obviously suggests the hypothesis that one and the same cause may produce this effect. This cause cannot be the structure of the chain, as the effect of introducing a given lateral chain is identical, though this structure be most different. The possibility of the existence of a so-called sterical hindrance is therefore discussed, and though on this hypothesis most of the phenomena may be explained, chemical factors are likely to play a not unimportant part as well. A. G.

2285. *Velocity of Formation of Simple Ethers.* **M. Rosenfeld-Freiberg.** (Jurn. Russk. Fisik. Chimičesk. Obščestva, 34. 4a. pp. 422–431, 1902.)—The author investigates the velocity of formation of simple ethers from the reaction of sulpho-benzolic ethers upon alcohols, it being shown that the constant velocity will undergo very regular variations, analogous to and in the same sense as those exhibited by physical properties, such as melting-points and specific weights, according to the nature of the sulpho-benzolic ether as well as the alcohol reacting, those constants decreasing from the methylic ether to the iso-amylic ether on the one hand, and from the methylic alcohol down to the octylic alcohol on the other, the latter confirming Zagrebin's views. In addition, great differences are found to exist between the constants corresponding to different modes of formation of one and the same mixed simple ether. A. G.

2286. *Micro-constituents of Steel.* **J. E. Stead.** (Engineering, 73. pp. 645–646, May 16, 1902.)—The original observation of Sorby, that properly hardened 0·9 per cent. carbon tool-steels, though they may be minutely crystalline are practically structureless, is correct. Roberts-Austen states that it requires a magnification of 1,000 diameters to exhibit the crystalline structure, and this is confirmed by the photographs of Osmond. The author has measured the sides of one of the crystalline triangles and finds it to be 0·0001 in., whilst many appear to be much smaller. After six hours' heating at 800° C. and quenching from 700° C., the crystals were thirty times larger. When small bars of steel are heated at one end to 800° or 900° C. for several hours the sections exhibit the effects of gradually changing temperatures, and the transition-point, &c., is very clearly shown. If the carbon is low (0·1 per cent.) and the original structure coarse, the point Ac_3 is also revealed, for at this point the coarse ferrite structure becomes broken up.

Between 620° and 670° segregation of the cementite and ferrite which compose the pearlite eutectic occurs, and a maximum of softness is obtained by annealing within these limits. T. M. L.

2287. *Alloys of Cadmium with Barium and with Calcium.* **H. Gautier.** (Comptes Rendus, 134. pp. 1054–1056, May 5, 1902.)—The author gives an account of the preparation of alloys of cadmium with calcium and barium, by the method already used by him for the corresponding strontium compound (C.R. 133, p. 1005). Cadmium and sodium are heated in a closed crucible for about two hours at a red heat, with the iodide of the alkaline earth metal; the alloy is thus obtained as a button containing about 16 per cent. to 18 per cent. of calcium or barium. The proportion of earth metal may be increased by distilling the alloy in vacuo; the calcium under similar conditions appears to be less volatile than strontium or barium, so that its alloys may be obtained with a percentage of 55 of calcium. The Ca-Cd and the Ba-Cd alloys are more brittle and less susceptible of potash than the Sr-Cd alloys. As described by the author in detail, the cadmium alloys of the earth metals behave quite similarly, to different chemical reagents. D. H. J.

2288. *Dissociation of Radio-active and other Elements.* **G. Martin.** (Chem. News, 85. pp. 205–206, May 2, 1902.)—The dissociation of the terrestrial elements at solar and stellar temperatures is represented by dissociation of the radio-active elements at ordinary terrestrial temperatures. There is a tendency to such dissociation among other elements, and is the greater the higher the temperature, and the greater the atomic weight within any Mendelejeff periodic group. At ordinary temperatures ferric chloride is the most stable form; at high temperatures ferrous chloride; the iron atom has shed one of its three electrons. Even at ordinary temperatures zinc sheds electrons, which can affect a photographic plate (Russell). Gases when heated to incandescence shed free electrons and become conductors of electricity; carbon increases greatly in conductivity at high temperatures; hot metals act like radio-active bodies in charging and discharging electroscopes. Probably atoms may break up into positively charged particles (deviable), negatively charged particles (deviable), and inactive particles composed of the unelectrified matter which composes the bulk of the atom. A. D.

2289. *Decomposition of Hydrated Mixed Crystals.* **R. Hollmann.** (Zeitschr. Phys. Chem. 40. pp. 561–576, May 13, 1902. Paper read before the 11. Kongress Russischer Naturforscher und Ärzte in St. Petersburg, Jan. 5, 1902.)—The transition-temperature of hydrated mixed crystals when in contact with the solution varies with the composition of the mixture. Three chief cases are possible in which (1) the transition-temperature of the mixed crystals lies between those of the components; (2) the decomposition curve shows a maximum, or (3) a minimum; these are again subdivided. If crystals of two degrees of hydration can separate from a solution together the mixed crystals of the higher hydrate are richer than those of the lower hydrate in the component which tends to raise the transition-temperature As an example of the first case the behaviour of the sulphates of manganese and zinc is quoted, the transition-temperature rising continuously from 10° ($MnSO_4 . 7H_2O$) to 40° ($ZnSO_4 . 7H_2O$). The sulphates of manganese and copper afford an example of a maximum in the curve. Retgers has shown that at about 10° a heptahydrate can exist in mixed crystals with 4·92–37·8

mols. per cent. of $CuSO_4$, whilst Stortenbeker working at 18° found these limits narrowed to 16–23·5 per cent. Cu, and "in summer weather" above 21° only the pentahydrate was formed; the maximum temperature at which a heptahydrate can exist is therefore at about 20° in crystals containing about 20 mols. per cent. $CuSO_4$. [See also Abstract No. 1143 (1902).] T. M. L.

2290. *Conductivity of Electrolytes with Univalent Ions in Aqueous Solution.* **F. Kohlrausch** and **H. v. Steinwehr.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 26. pp. 581–587, May 29, 1902.)—Very accurate measurements of the conductivity of salts containing the ions K, Na, Li, Cl, NO_3, IO_3, have already been made [see Abstracts Nos. 250 (1900), and 913 (1901)]; similar measurements have now been made in the case of the salts CsCl, TlCl, KI, KBr, KCNS, KF, NaF, TlF, $TlNO_3$, $AgNO_3$ and $KClO_3$. The solutions examined varied in strength from normal to N/10000, and the values of the equivalent conductivity $\Lambda\infty$ at infinite dilution were deduced by means of the formula $\Lambda\infty - \Lambda/\Lambda^{\frac{1}{2}} = C.m^{\frac{1}{2}}$ from the values observed in the very dilute solutions. From the values of $\Lambda\infty$ now deduced the ionic mobilities of the ions Cs, Ag, Tl, I, Br, CNS, F and ClO, can be accurately determined.

The following table gives the accurate values now adopted for the mobilities of the univalent ions:—

Li	Na	K	Rb	Cs	NH_4	Tl	Ag	F	Cl	Br	I	CNS	NO_3	ClO_3	IO_3
33·44	43·55	64·67	67·6	68·2	64·4	66·00	54·02	46·64	65·44	67·63	66·40	56·63	61·78	55·03	33·87

whilst less accurately determined values are BrO_3 46·2, ClO_4 64·7, IO_4 47·7, MnO_4 53·4, and for the radicles of the fatty acids—

CHO_2	$C_2H_3O_2$	$C_3H_5O_2$	$C_4H_7O_2$	$C_5H_9O_2$	$C_6H_{11}O_2$
46·7	35·0	31·0	27·6	25·7	24·3

In the case of thallium fluoride values of the equivalent conductivity were obtained which in the case of solutions more dilute than N/500 were greater than the sum of the ionic mobilities. This is probably due to hydrolytic dissociation of the salt giving rise to thallium hydroxide and hydrogen fluoride. T. M. L.

2291. *Temperature Variations of Specific Molecular Conductivity and of Fluidity of Sodium Chloride Solutions.* **T. R. Lyle** and **R. Hosking.** (Phil. Mag. 3. pp. 487–498, May, 1902.)—Determinations were made between 0° and 100° of the density, fluidity, and conductivity of sodium chloride solutions, the three instruments being contained in one bath, and measurements made every 10° C. The values obtained were corrected for the change of concentration due to expansion, and smoothed values of the density, fluidity, and conductivity are given for each 10° from 0° to 100° (also for 15° and 18°) for concentrations 0·1, 0·2, 0·5, 1·0, 2·0, and 4·0 normal, and also by extrapolation for solutions of infinite dilution ($n = 0·0$). The curves showing the influence of temperature on conductivity would indicate that for solutions of the strengths experimented with, both properties would tend to a zero value at −35·5° C. [See Abstract No. 524 (1902).] But the curves representing the two properties are by no means identical, the fluidity in all cases increasing much more rapidly than the conductivity as the temperature rises. The ratio conductivity/fluidity has a temperature coefficient which is of the same order of magnitude for all concentrations averaging 0·00174,

and the formula $u(1 - 0{\cdot}000174t)$, where u depends only on the concentration, serves to express the ratio with an average error of 1 per cent.

The (molecular) conductivity-concentration and fluidity-concentration isothermals are also approximately straight lines, which if produced would intersect the axis of concentration at 10·74N. This would indicate that if the laws observed up to concentration 4N should continue to hold good, the fluidity and molecular-conductivity would disappear at this concentration. The deviations from the linear law are greatest in dilute solutions at 0° C. and 100° C.

T. M. L.

2292. *Temperature Coefficients of the Ionic Mobilities in Water with a Law for Univalent Monatomic Ions.* **F. Kohlrausch.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 26. pp. 572–580, May 29, 1902.)—The following table gives the values now adopted for the ionic mobilities l_{18} and their temperature coefficients $a_{18} = \frac{1}{l}\frac{dl}{dt}$ at 18° C.:—

	l_{18}	a_{18}		l_{18}	a_{18}
Li	33·44	0·0265	NH_4.....	54·4	0·0222
Na	43·55	0·0244	$C_5H_9O_2$	25·7	0·0244
F.....	46·64	0·0238	$C_2H_3O_2$	35·0	0·0238
Ag	54·02	0·0229	IO_3	33·87	0·0234
K.....	64·67	0·0217	ClO_3.....	55·03	0·0215
Cl	65·44	0·0216	NO_3.....	61·78	0·0295
Tl	66·00	0·0215	OH	174	0·0180
I	66·40	0·0213	$\frac{1}{2}$ Zn.....	45·6	0·0251
Br	67·63	0·0215	$\frac{1}{2}$ Mg	46·0	0·0256
Rb	67·6	0·0214	$\frac{1}{2}$ Br	56·3	0·0238
Cs	68·2	0·0212	$\frac{1}{2}$ Pb	61·5	0·0243
H.....	318	0·0153	$\frac{1}{2}$ SO_4	68·7	0·0227
CNS	56·63	0·0221	$\frac{1}{2}$ CO_3	[70]	[0·0270]

In the case of the univalent monatomic ions these constants are related to one another; if plotted as ordinates and abscissæ the values yield a regular curve which can be expressed by the equation $a = 0{\cdot}03536 - 0{\cdot}000329l + 0{\cdot}0000018l^2$. This equation does not include the value for the hydrogen ion, with a mobility nearly five times as great as that of Cs, but a slightly less accurate equation $(a - 0{\cdot}0132)(l + 22) = 0{\cdot}73$ can be used to include the hydrogen value; it is possible, however, that the highly mobile ions H and OH, which are also the ions of the solvent, should not be included in this law. The law holds good approximately for NH_4 and CNS, but the polyatomic anions $C_5H_9O_2$, $C_2H_3O_2$, IO_3, ClO_3, and NO_3 have smaller temperature coefficients, and the divalent ions, Zn, Mg, Ba, Pb, SO_4, and CO_3 have greater temperature coefficients than those calculated from the equation given above. With rising temperature, the mobilities of the different ions tend to become equal, and the transport value of a salt changes slightly therefore in the direction of the value 0·5. In order to explain the simple relationship between the mobility and its temperature coefficient, it is suggested that the ions are surrounded by a watery "atmosphere," and that the friction is between the solvent water and this atmosphere rather than the simple ion.

T. M. L.

2293. *Polarising Capacity of Palladium.* **M. Wien.** (Ann. d. Physik, 8. 2. pp. 372–387, May, 1902.)—To explain the increase of resistance which

takes place in an electrolytic cell through which an alternating current is passed, there is assumed to be a phase-difference between the impressed and the polarisation currents. As regards behaviour, three groups of cells are distinguished, typified respectively by (1) Pt electrodes, (2) unpolarisable electrodes, and (3) platinised Pt electrodes. Warburg's theory for group 2 gives fair results for the polarisation capacity, and has been extended to include groups 2 and 3. An expression is given which sums up his results. In the first of two limiting cases considered, the polarisation capacity is independent of the frequency (group 1). In the second, the phase-difference is constant $\left(=\frac{\pi}{4}\right)$, and the capacity inversely proportional to $\sqrt{}$(frequency). To test the theory better, palladium wires are used along with a more extended range of frequency (64 to 1,024), the method being the same as formerly used (Ann. d. Phys. 4. p. 429, 1901). The wires were sealed in a parallel position in a special glass vessel so that they could be annealed electrically, the vessel being connected with an air-pump; or the vessel could be filled with liquid, the electrolyte used being H_2SO_4 of maximum conductivity. No substantial difference was found to exist between ordinary Pd and Pt, the phase-difference being small, and almost independent of the frequency. But platinised Pt electrodes behaved like smooth ones of greater surface, and Pd electrodes covered with palladium black gave a much higher polarisation capacity and phase-difference than the platinised Pt electrodes. When the palladium black is deposited from a solution to which lead acetate has not been added as was done in the previous cases, it was found, among other things, that it depends on the amount of occluded hydrogen present whether the electrodes approach limiting case 1 or 2. G. E. A.

2294. *Ratio of Distribution of a Base between Two Acids.* **H. M. Dawson** and **F. E. Grant.** (Chem. Soc., Journ. 81. and 82. pp. 512–521, May, 1902.)—Acetic acid is soluble to some extent in chloroform, while tartaric, malic, citric, and succinic acids are not. The sodium salts of none of the above acids are soluble in chloroform. Hence if an aqueous solution containing, say, free acetic and tartaric acids and their sodium salts, be shaken up at a constant temperature with chloroform, and if the distribution ratio of acetic acid between chloroform and water be known as a function of the concentration (from previous experiments), the concentration of the "free" acetic acid in the aqueous solution can be determined, and the distribution of the base between the two acids calculated. The authors determined the disturbing effect due to the presence of the salts and the other acid in the aqueous solution, and found it sufficiently small to be neglected in this preliminary investigation. For the sake of simplicity, the authors explicitly dispense with any introduction of ionisation-coefficients. The values found for the relative avidities of the above-mentioned acids, at a concentration of 0·3 normal, agree very well with the values found by Ostwald, by the volume method, at a concentration of 0·33 normal, but the values obtained by the new method at a concentration of 0·1 normal do not agree with the numbers obtained from Ostwald's experiments on the solubility of calcium oxalate in acids of this concentration. It is pointed out, however, that the relative avidities or strengths obtained by Ostwald in the latter way for a concentration of 0·1 normal can scarcely be reconciled with the corresponding values obtained by the volume method for a concentration of 0·33 normal, since the alteration in the two series of values is too great for such a comparatively small change of concentration. F. G. D.

2295. *Electrical Laboratory Furnace.* **W. C. Heraeus.** (Zeitschr. Elektrochem. 8. pp. 201–203, April 10, 1902.)—A description is given of a new form of electric furnace, consisting of a porcelain tube wrapped round with platinum-foil, which is heated by means of a current. It has several advantages over platinum wire. (1) Contact is more easily obtained between the tube and the heated foil, and therefore the temperature of the tube is more nearly equal to that of the platinum than is the case when wire is used; (2) there is less liability to overheating, and consequent melting of the platinum; (3) decreased cost. The most suitable foil is that of which a square decimeter weighs about 1·5 grams, and of which the thickness is 0·007 mm. If wire is used the weight required is about six times that of the foil. A temperature of 1,500° C. can be obtained, and kept constant, without damage to the furnace. Finally, the oxygen in the tube may be replaced by a continuous current of an indifferent gas. W. C. B.

2296. *Photogalvanography.* **N. Piltschikoff.** (International Physical Congress at Paris, Report, 4. pp. 74–76, 1900–1901.)—If a zinc anode and a solution of zinc have with them a kathode of polished copper slightly oxidised, the zinc is deposited more thickly on the more brightly lit parts of the copper. With sunlight shadows silhouettes can thus be made instantaneously. This leads to suggestions of various practical processes. A. D.

2297. *Harmet Process for the Production of Steel direct from the Ore.* (Electro-Chemist, 2. pp. 93–95, May, 1902.)—In a paper read before the Société de l'Industrie Minérale de Saint-Etienne on April 5, 1902, Harmet deals with the reduction of iron ores in a furnace in which the whole of the necessary heat is electrically generated, the only quantity of coke introduced being that strictly necessary for production of the reducing gases. Ore and flux are fed into a drying or calcining kiln to be freed from water, carbon dioxide, and other volatile materials, and heated to redness by means of blowpipes. The burning gases from the latter pass through the whole mass before escaping to the atmosphere, the red-hot material being forced through low lateral passages by means of a piston into hoppers, and thence to the reducing furnace proper. The coke is heated before being fed into the furnace, the hot mixture of coke, ore, and flux slowly descending into a shaft. To ensure complete reduction before the mixture reaches the hearth, the gases generated by the combustion of the coke are drawn out at the head of the furnace, and forced by a blowing machine through a tube communicating with the base of the furnace, where carbon dioxide, in presence of red-hot coke, is reduced to the monoxide, which besides serving the part of a powerful reducing agent, also acts as a vehicle for the heat electrically produced on the hearth, and not absorbed by the fusion of the iron. Tables are given showing thermic equivalents of two methods of treatment of a given mixture, as well as sketches of the furnace details. [See also Abstract No. 1399 (1902).] O. J. S.

2298. *The Elmore Copper-Depositing Process at Leeds.* (Engineering, 73. pp. 633–634, May 16, 1902.)—This is an illustrated description of the reorganised works of the English Electrometallurgical Company at Hunslet, near Leeds. The original company was established in 1889 to work the Elmore patent for depositing copper on revolving mandrils, a dense deposit being obtained by means of travelling agate burnishers. In 1900 the company and its finances were reorganised, and £200,000 additional capital was

put into the business. The depositing plant now consists of 4 × 250 h.p. Bollinckx cross-compound condensing engines with Corliss valves, driving by rope-gearing 4 × 170 kw. Brown-Boveri dynamos yielding continuous current. The mechanical power plant consists of 3 × 400 h.p. Bollinckx engines, driving Brown-Boveri dynamos of equivalent power. The depositing vats are 216 in number, and suffice to deposit 75 tons of copper per week. Agate burnishers are still used, but in some cases the deposited tubes are drawn down after removing from the mandrils. The anodes are cast from Chili bar copper, testing 96 per cent., and these bars are submitted to a preliminary smelting to remove arsenic. A large number of mechanical tests of the deposited copper are given. These vary from 14 to 22½ tons per sq. in., the highest tensile strength being attained with a sample of a burnished tube annealed and drawn down once before testing. J. B. C. K.

2299. *Electrolytic Treatment of Tin-Scrap by the Lode Process.* **H. Mennicke.** (Zeitschr. Elektrochem. 8. pp. 315–320, May 22; 357–370, June 5; and pp. 381–395, June 12, 1902.)—In this series of articles the author deals with the chemistry and practice of the electrolytic recovery of tin from tin-scrap in a most exhaustive manner. Germany possesses seven works operating processes of this character, and 30,000 tons of tin-scrap are reported to be treated annually. The cuttings and scrap which form the raw material for these recovery works are drawn from England, France, and Switzerland, and the average percentage of tin contained in the scrap does not exceed 3·5. The author discusses the various electrolytes which have been suggested for stripping the tin, and decides in favour of a simple sodium hydrate solution. This electrolyte yields a solution of sodium stannate on passing a current through the cell, and from this solution, tin can be deposited at the kathode in a spongy state, without any risk of contamination by iron. The addition of sodium chloride to the sodium hydrate solution has been suggested by some authorities, but although such addition increases the solvent action at the anode, it is not recommended by the author, since it increases the danger of obtaining an impure deposit of tin at the kathode. The maximum recovery of tin possible by the sodium hydrate process is, according to the author, 88 per cent. A tin recovery works, designed for the annual treatment of 9,000 tons of scrap, would require 60 cells, each of about 3 cubic metres capacity, and each cell when fully charged would contain 150 kg. of scrap, packed in the usual type of lattice-work baskets. The author has carried out a large number of experiments relating to the conditions, as regards current density and temperature, which must be observed in order to obtain the best results with the alkaline process, and full details of these are given in the original articles. J. B. C. K.

REFERENCE.

2300. *Electrolytic Reduction of Aromatic and Fatty Nitrobodies.* **J. Möller.** (Elektrochem. Zeitschr. 8. pp. 239–244, Feb.; 272–275, March; 9. pp. 7–11, April; and pp. 27–35, May, 1902.)—This series of papers gives an account, chiefly from the chemical point of view, of the different known cases of reduction of nitro-compounds, whether in alkaline or acid solutions. The views of Löb, Haber, and Chilesotti on the exact course of the reduction are also given. D. H. J.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

2301. *Engine Requirements for the Parallel Operation of Alternators.* **H. E. Longwell.** (Street Rly. Rev. 12. pp. 358–361, June, 1902. Paper read before the Engine Builders' Association of the United States, at the Annual Meeting held in Pittsburg, Pa., May 22 and 23, 1902.)—In this paper the author starts with the assumption that there will always be a certain amount of irregularity in the engine speed, both cyclical and in successive revolutions, which will necessarily produce some transfer of energy from one alternator to another, and that it is therefore useless in discussing the question of parallel running to assume perfectly uniform speed. The cross currents can never be entirely eliminated; all that can be done is to reduce them as much as possible. It is incorrect to say that bad parallel running is ever due to hunting, or otherwise faulty governors, though these may aggravate the evil; as a fact, the most perfect governor from an engine-builder's point of view is the worst for parallel operation, since the duty imposed on it under these conditions is directly opposed to its natural function. The leading machine tends to take more of the load, and ought therefore, for equilibrium to be restored, to have its steam supply decreased, but the natural tendency of the governor is precisely the opposite. Hence it must be rendered sluggish by dash-pots and similar devices. Referring to the uniformity of angular speed, which is usually considered essential, the author criticises the Westinghouse specification [see Abstract No. 1942 (1902)] on the ground that it is unreasonable to demand the same limit for angular speed variation in all cases, when generators vary so greatly in their electrical characteristics. The short circuit current of some generators is as low as two and a half times the full load current, while that of others may be six times the full load current. With the same maximum flywheel displacement, the cross-currents in the latter case will be much greater than in the former; hence either the allowable displacement is too small in the former case, or it is too much in the latter. The question of synchronising force is next discussed, the assertion being made that in every practical case its effect is to *increase* the irregularity of the angular speed of the engine instead of diminishing it. An instance of this seeming paradox is cited, where by decreasing the terminal pressure of a two-phase alternator by weakening the field the parallel running was greatly improved, so that both phases could be coupled in parallel, whereas with normal excitation it was impossible to parallel on more than one phase. By means of a diagram this result is shown to be what was theoretically to be expected. Starting with the curve of crank effort, approximately sinoidal, a second curve is obtained by integration, the ordinates of which represent the velocity of the crank-pin above and below the mean velocity. This velocity curve is clearly also sinoidal, lagging 90° behind the curve of crank effort. Integrating the velocity curve, a third curve is obtained, the ordinates of which represent displacement in front of

or behind the position corresponding to uniform velocity; this curve is also sinoidal, and lags 90° behind the velocity curve, and therefore 180° behind the curve of crank effort. Thus, when this latter is at a maximum and the surplus energy is accelerating the rotating masses, these are always at their maximum displacement *behind* the position corresponding to uniform angular speed, and *vice versâ*. But since the synchronising force due to cross-currents is proportional to the displacement, and tends to accelerate the rotating masses when these are behind the mean position, and to retard them when they are in advance of it, it follows that the synchronising force is acting in unison with the crank-pin effort, and hence tends to increase the displacement. The amount by which this is increased depends to a large extent on the natural oscillation period of the rotating masses. B. P. S.

2302. *Tests of a Sulzer Engine.* **M. Schröter.** (Zeitschr. Vereines Deutsch. Ing. 46. pp. 891–896, June 14, 1902.)—This engine was a 1,000-h.p. tandem compound. The diagrams given in the article for the front and back of both cylinders were constructed by taking an arithmetic mean of several indicator diagrams, &c. The steam pressure used was 10·5 kg. per sq. cm. abs. and trials were made with saturated steam at about 180° C., and with superheated steam at about 180 + 100° C. Curves of the relation between cut-off and h.p. show that, with similar conditions, saturated steam produces a somewhat greater gross h.p. The exponents in the formula $PV^n = \text{constant}$ are worked out in each case for the compression, and for two stages of the expansion in each cylinder. With saturated steam the "n" for expansion varied from 0·95 to 1·13 (mean about 1), and with superheated steam from 1·0 to 1·9 (mean about 1·3). Reduced indicator diagrams, with theoretical curves added, are given and discussed. In order to allow for leakage past valves and piston, the author made an auxiliary test with Doerfel's method (Z. V. D. I., 1899, p. 601, &c.). The author considers that with such high-class engines it may be assumed that the quantity of steam in the clearance space and at the beginning of the stroke can be deduced with accuracy from indicator diagrams. A large amount of tabulated data is given and discussed. The author has considered the difference in the cooling surfaces and clearances at the different ends of the cylinders, and he deduces from the experiments that the earlier the cut-off the higher the superheat needed to ensure dry steam at the beginning of expansion. Finally, the author works out thermal efficiencies: (1) For the Clausius-Rankine cycle with similar pressures, &c.; (2) for the actual engine with (*a*) feed-water temperature as a basis, (*b*) 0° C. as outlet temperature (see Z. V. D. I., 1899, p. 605, by Doerfel), (*c*) 20° C. as outlet temperature (Mollier). The maximum brake efficiencies which are given, according to (2)*a*, are 0·157 for saturated, and 0·167 for superheated steam. The steam consumption per i.h.p.-hour was 6·2 kg. (mean) with saturated, and 5·24 kg. with superheated steam, including jackets and leakage. R. C. R

2303. *Schmidt System of Superheating Steam.* (Elect. Engin. 29. pp. 837–839, June 13, 1902.)—The article contains some facts as to recent progress of this system in Britain, gives illustrations of independently fired superheaters and the full text of a report by Prof. **J. A. Ewing** on trials carried out by him at Erith with a triple expansion engine having a jacketed receiver between the intermediate and low-pressure cylinders, in which the superheated steam on its way to the high-pressure cylinder was used to dry and

heat the steam passing to the low-pressure cylinders. The principal data of the trials were as follows :—

Trials.		A	B	C	D	E
Electrical output in kw.		140·2	104 0	67·3	41·2	10·0
Lbs. of steam condensed per hour		2,570	1,940	1,367	1,004	663
Lbs. of steam per kw.-hour		18·3	18·5	20·3	24·4	—
Pressure at stop valve, lbs. per sq. in.		129	130	131	126	82
Temperature at stop valve	C.°	376	371	368	352	295
	F.°	709	700	694	666	583
Temperature of high-pressure steam after receiver	C.°	316	305	298	293	255
	F.°	601	581	568	559	491
Temperature at intermediate cylinder exhaust	C.°	141	128	121	118	118
	F.°	286	263	250	245	245
Mean temperature at l.p. cylinder inlets	C.°	203	193	184	174	159
	F.°	397	380	363	345	318
Vacuum, inches		23·15	23·5	23 8	23·8	22·7
Barometer, inches		29·6	29·6	29·6	29·6	29·6
Indicated h.p.		226	—	—	—	—
Electrical h.p.		188	—	—	—	—
Ratio of electrical to indicated h.p.		0·83	—	—	—	—
Lbs. of steam per i.h.p.-hour		11·4	—	—	—	—

The quantity of steam used per hour in the trials in relation to the electrical output is shown graphically in the following diagram :—

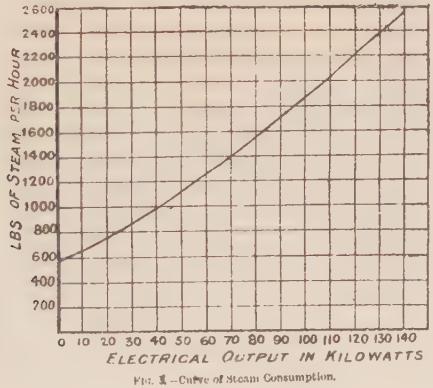


FIG. 1.—Curve of Steam Consumption.

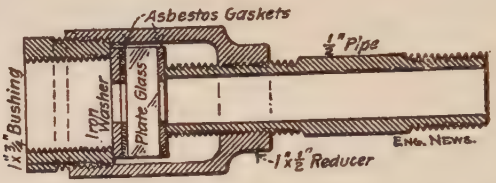
From the curve, the number of lbs. of steam used per electrical unit generated at the various grades of output are thus :—

Kilowatts.	Pounds of Steam used per Electrical Unit.	Kilowatts.	Pounds of Steam used per Electrical Unit.
140	18·3	60	20·8
120	18·5	40	24·5
100	18·7	20	38·0
80	19·4		

With a higher boiler pressure better results would have been obtained, but the steam consumption per kw. is remarkably good. [See also Abstracts Nos. 2303 (1900), 938, 2231 (1901), 150, 1406 (1902).] F. J. R.

GAS AND OIL ENGINES.

2304. *Device for Examining the Interior of Gas-Engine Cylinders while Running.* **W. T. Magruder.** (Eng. News, 47. p. 385, May 15, 1902. Reprinted from "The Gas Engine" for March.)—Into the rear head is screwed a pipe nipple, of say ½-in. iron pipe size, and having a long thread on one end, which is screwed into a 1-in. × 1½-in. reducer, into the outer end of which is screwed a 1-in. × ¾-in. bushing used as a stuffing-box nut in holding a piece of thick plate-glass in position at the end of the ½-in. nipple. The glass is separated



from the nipple, and from the iron washer of the stuffing box, by means of asbestos gaskets. To prevent breakage from overheating, the glass should be several inches from the inner side of the cylinder head, and small enough not to touch the inside of the reducer. With this apparatus, the construction of which is shown in the accompanying diagram, the blue flame characteristic of complete combustion can easily be distinguished from the yellow flame that indicates the presence of incandescent carbon. G. W. DE T.

AUTOMOBILISM.[1]

2305. *Chenard-Walcker Motor Carriage.* (France Automobile, 7. pp. 232–235, April 12, 1902.)—In this carriage, which is described in detail in the article, the main feature consists in the mounting of the motor and transmission gear symmetrically about the longitudinal vertical plane midway between the pairs of wheels, the object being to minimise the effects of vibration and to enable the working parts to be placed high above the ground so as to render them easy of access for examination or adjustment. The transmission shaft is divided into two parts, situated one above the other and connected by the change-speed gear, which is completely enclosed in an oil bath. This gearing is arranged for three forward speeds and one reverse speed, and is designed so as to minimise flexure of the shaft as much as possible in effecting the speed changes. The front portion of the transmission shaft is coupled to the motor flywheel by means of a spring friction clutch coupling, which may be disengaged by means of a foot lever. The rear part of the shaft is articulated and drives, through bevel gear, a live axle, supported above the rear axle, which is fixed. This live axle transmits power to the hubs of the rear wheels by means of spur gear. The article is illustrated by views of the various working parts of the vehicle. J. G.

2306. *Ader Light Automobile.* **L. Fournier.** (Locomotion Automobile, 9. pp. 230–233, April 10, 1902.)—This article deals with the 8-h.p. type of Ader vehicle constructed by the Société Industrielle des Téléphones. The motor is of the four-cycle type, and has two cylinders arranged at an angle to each

[1] Electric Automobiles are described in the Section dealing with Electric Traction.

other, in a vertical plane. Power is transmitted from the motor through change speed and bevel gear to a countershaft, from which the rear axle is driven by means of a chain transmission. Two brakes are fitted—one, a foot-operated brake, being applied to the rear axle and working on pulleys attached to the differential gear, and the other, a hand-operated brake, having action upon the front axle. The brake-controlling gear is arranged so that when the brakes are brought into action the supply of explosive charge to the motor cylinders is simultaneously reduced. The chief feature of note in this vehicle is the vapouriser, which is an adaptation of the old wick type hitherto little used. It consists of a chamber in which the oil supplied is maintained at a constant level by means of a float-controlled valve. A number of wicks dipping into the oil are suspended from the top of the chamber, which is removable, and carburation is effected by the aspiration of air through the wicks. The vapour formed is supplied to a mixing valve, where a further supply of air is added to form the explosive mixture for the motor cylinder. Lighting back from the cylinder through the mixing valve is prevented by means of wire gauze screens placed across the outlet from the mixing valve. The discharge from the motor cylinders takes place through an exhaust silencer consisting of four concentric tubes enclosed in a chamber, the gases passing successively through the tubes before escaping to atmosphere. The article is accompanied by illustrations of the mechanism. J. G.

2307. *Daimler Cars.* (Automotor Journal, 7. pp. 357–360, July 20, and pp. 384–387, Aug. 2, 1902.)—A complete description is given of the "1902" types of cars manufactured by the English Daimler Motor Company. The chief types are a 9-h.p. car with double-cylinder engine, and 12-h.p. and 22-h.p. cars with four-cylinder engines. The general arrangement of the mechanism is identical in all cases. The main frame, sprung from the axles on semi-elliptic springs, is constructed of wood reinforced with steel plates. A subsidiary frame of angle steel is hung from the main frame towards its front end, and carries the engine and friction clutch. The shaft carrying the male portion of the clutch is coupled to the lower shaft of the change-speed gear by an adjustable coupling, and motion is transmitted to the upper gear shaft by one of four sets of spur-wheels, which correspond to three forward speeds and one reverse speed. The differential cross-shaft, which is in front of the main portion of the gear-box, is driven by bevel gearing from the upper spur-wheel shaft. The final transmission is by independent chains to the rear road wheels. The weight of the chains in the 9 and 12-h.p. cars is from 14 to 15 cwt., and about 22 cwt. in the 22-h.p. car. In the 9-h.p. engine the cylinders are 105 mm. bore × 100 mm. stroke, both pistons being coupled to a single crank pin on a shaft in which the engine flywheels form the crank webs. The 12-h.p. engine has cylinders 86 mm. bore × 100 mm. stroke, and the normal speed is 930 r.p.m.; and the 22-h.p. engine cylinders are 105 mm. bore × 130 mm. stroke, normal speed 720 r.p.m. Both these engines have external flywheels. C. R. D'E.

2308. *Barton's Airship.* (Engineer, 93. p. 392, April 18, 1902.)—Its largest diameter is about $\frac{2}{3}$ from the front end, it is 180 ft. long and 41 ft. diameter, capacity 156,000 cubic ft.; this gives a lifting capacity of 10,080 lbs. The upper surface is enveloped in a chemise provided with cane stiffeners, from which the car is suspended. The ship is propelled by six two-bladed triple fans. Each pair of fans will be driven by an oil motor, exerting 45 b.h.p. Mr. Alexander's experiments at Bath show that a thrust of 25 lbs. per b.h.p. can be obtained

In this instance the thrust is taken as 20, giving a total of 2,700 lbs. for the six fans. There are three sets of aeroplanes, each set consisting of three, one over the other, each aeroplane having a rod in front for the pivot and a rod in the rear for raising and lowering the end by links. The deck remains horizontal by means of water-tanks at each end, each contains 50 gallons of water which is kept, by means of a pump and connecting pipes, in a constant state of circulation. A pendulum-operated valve is arranged so that should one end of the deck drop, the pendulum shuts off the water from the lower end and pumps it to the upper tank till the level of the deck is restored.

	lbs.
Envelope with chemise and attachments	1,900
Subsidiary balloon	140
Five men	800
Motor spirit 216 gallons	1,460
Six 17-ft. fans	500
Three 45-b.h.p. engines	1,150
Deck, superstructure, and aeroplanes	3,500
Instruments, goods, clothing, and sundries	150
Total	9,600

The area of the balloon is 1,320 sq. ft. According to Rouse and Smeaton, the air-resistance of a flat surface at 13 miles per hour is just under 1 lb. per sq. ft. Langley showed that this amount is excessive. The pressure is reduced if the object is in the form of a cone, and the resistance is variously given as from one-third to one-fifth of a flat surface. Therefore the resistance is under 700 lbs. The thrust available is 2,700 lbs., and we may expect a speed exceeding 20 miles per hour. M. O'G.

REFERENCES.

2309. *Rocking Valves and Valve Gears.* **H. F. Schmidt.** (Amer. Electn. 14. pp. 265–277, June, 1902.)—The author considers the principal types of valves and valve gears employed in modern steam-engine practice, together with the reasons for the modifications of the original Corliss type of valve and gear. The paper is accompanied by sixty-two diagrams and other illustrations. G. W. DE T.

2310. *Oil as Fuel.* (Street Rly. Rev. 12. pp. 322–325, June. 1902.)—Contains data of tests from New Orleans, Mobile, and El Paso. [See Abstracts Nos. 950, 1766 and 1944 (1902).] F. J. R.

2311. *Steam-raising from London Refuse.* (Elect. Rev. 50. pp. 929–930, June 6, 1902.)—The paper gives results of a seven hours' test of Meldrum's "Simplex" destructors with steam boilers, as regards raising steam from London refuse. [See also Abstracts Nos. 1138, 1726, and 2330 (1900), 204 and 2288 (1901), and 761 and 949 (1902).] F. J. R.

2312. *Gas Engines for Central Stations.* **C. H. Williams.** (West. Electn. 30. p. 427, June 14, 1902. Abstract of a paper read before the National Electric Light Association at Cincinnati, Ohio, May 22, 1902.)—The author reviews the advantages of gas engines [passing lightly over their disadvantages], and suggests possibilities of utilising part of the heat carried away in the cooling water. H. R. C.

GENERAL ELECTRICAL ENGINEERING.

2313. *Small Accumulator Charging Device.* (Motorwagen, 5. pp. 105–106, April 15, 1902.)—This article describes an arrangement for charging small accumulators, such as those employed for ignition purposes on automobiles. It consists of a permanent magnet dynamo, the shaft of which is vertical and coupled to the arms of a small reaction turbine. These arms rotate inside of an aluminium ring against the interior of which the discharged water impinges. The whole turbine is enclosed in a glass case fitted with inlet and delivery water connections.

The following table gives the dimensions and output of the three types built by the designers (Roth and Benninghoven).

Type.	Capacity (Watts).	Water Consumption (Litres per hour).	Turbine Ring	
			Dia. in mm.	Height in mm.
I.....	4	200	150	70
II.....	2	100	95	60
III.....	1	50	50	40

J. G.

2314. *Mordey-Fricker Meter.* (Electrician, 49. pp. 131–133, May 16, 1902.)—The meter consists of a clock deprived of its hair-spring, and carrying on its balance-wheel shaft a disc of slate, on which a few pieces of iron wire are fixed in the manner of a compass card. This disc is surrounded by a fixed coil of wire conveying the current to be metered. The disc acts as a variable hair-spring; the iron which it carries is magnetised more or less strongly by the current, a directive force being exerted in an opposite sense to that acting on a galvanometer needle—that is to say, tending to bring the iron needle to an axial position in the coil. This action, in conjunction with the ordinary action of the driving spring of the clock, causes the disc to oscillate at a rate directly proportional to the current. The meter does not go at all when no current is passing, for there being then no directive action on the iron, the disc comes to rest at one or the other extreme of its arc of oscillation. The balance-wheel shaft rests on a footstep jewel, but to avoid risk of injury to this in carriage, the greater part of the weight is taken off it by a silk fibre suspension. The meter has a range of from 1 to about 15, and is primarily intended for small installations, say up to 30 lamps, where, if 15 lamps is the maximum load, the meter will record with one lamp. It is also applicable to motor installations, the no-load current being sufficient to start the meter. The meter can be used on direct or alternating currents, and curves of the constant are given for both currents. In the alternate-current meter the error is nil from 0·6 to 2·4 amperes, 5 per cent. at 0·3, and 1·5 per cent. at 2·6 amperes. The curve for direct current is rather different, the error being nil at 0·3, 1·4 and 2·3 amperes. G. H. B.

2315. *Starting Resistances.* **A. E. Gott.** (Inst. Elect. Engin., Journ. 31. pp. 1220–1230; Discussion, pp. 1230–1233, June, 1902.) (Abstract.)—The author considers the construction of motor-starting switches, deals with various types of starters, and criticises the methods on which their designs are based. The early switches were apt to throw serious strains on the motor

and the starter, and in modern designs there was still room for considerable improvement. The resistance of the steps should be divided so as to limit the increase between steps to a definite amount, the general rule being stated by the formula $a \times f^n =$ total resistance, where $a =$ armature resistance; $f =$ common factor; and $n =$ number of sections of resistance. In practice, however, this needed modifying to $f^n = R/9, f = \sqrt{(R/9)}$, in order to meet the conditions of manufacture, these latter calling for numerous alterations in design. For high voltages, the sparking between contacts could be reduced by limiting the p.d. to a predetermined amount, and when this figure did not exceed 30 to 35 volts the sparking became inappreciable. The contacts might also be placed as close as $\frac{1}{16}$ in. asunder, and even when the switch was moved backwards to re-insert resistance, the arc could not be maintained across the gap. The barrel type of controller was considered the worst in use, as the diameter of the barrel was limited to about 6 in., and the steps were correspondingly reduced between off and full on. Geometrical division of the sections was not possible, as, although the current increment could be equalised, the high voltage on the first contacts caused serious burning. A compromise could be made by reducing the current increment on the first steps (and consequently the voltage) and increasing both at the armature end. Liquid resistances, when carefully designed, afforded the most perfect method of control, particularly with reversing motors. Certain difficulties, however, existed, which might be overcome by enamelling the pot half-way down and arranging the dipping-plate to pass between two other plates cast into the sides of the pot. The enamel compelled the current to pass through a greater length of solution at starting, and gave much better control. Resistances of this type were in constant use on voltages up to 500 with every satisfaction.

W. E. W.

2316. *Selector Switch.* (Electrician, 49. pp. 133–134, May 16, 1902.)—The switch is primarily intended for switching on or off arc-lighting circuits. Each arc-light circuit is provided with a switch apparatus, these being connected in series by a circuit including a transmitter in the station. The transmitter has a number of pairs of contact discs on a spindle, which is turned through one revolution on winding up a spring by a lever. Each pair of discs corresponds with one of the automatic switches, and this is operated by moving a pair of contact fingers to the disc in question and working the lever. The contact disc in rotating sends a number of current impulses; for a 10-switch apparatus, there are 22 in one direction and 7 in the reverse direction. The moments at which the reverse impulses are sent differ for each switch, and only that switch is operated to which the particular series of impulses sent corresponds.

The automatic switches have each a selector, consisting of a polarised electromagnet, which for, say positive currents, moves a disc round by means of a ratchet, one tooth at every impulse; the disc is moved against a spring, and is held by a detent. When a negative current is sent, the detent is lifted, and if the switch is not the one for which the particular series of impulses is intended, the disc returns to its original position. If, however, it be the corresponding switch, another detent engages in a notch in a plate fixed to the disc, and holds the disc in position. The result of the 22 positive impulses is to rotate the disc of the corresponding switch, and that of no other, through a half-turn. At the half-turn a ratchet fixed to the disc engages in a snail on a barrel of fibre carrying a contact piece, and this turns with the disc, when a final negative impulse releases the latter. The contact piece in

turning makes contact with a spring finger and completes the circuit of an automatic switch. At Croydon, where the system is now working, current is taken from the station battery for the selector circuit, and from the private lighting network for the automatic switches. G. H. B.

2317. *Safety Devices for Protecting Insulated Conductors against Excessive Electric Pressures.* **G. Benischke.** (Elektrotechn. Zeitschr. 23. pp. 552–555; Discussion, p. 555, June 19, 1902. Paper read before the Elektrotechn. Verein, March 25, 1902.)—The author first discusses how excessive pressures may be produced, and explains the effects which take place in the secondary of a transformer when the circuit is broken at times corresponding to different points on the current curve of the primary circuit; also the effect in switching in and out transformers and motors, &c. The apparatus described includes several arrangements similar to that referred to in Abstract No. 395 (1902), further details being given of the water resistances employed. Another form of safety-device, suitable for use on low-pressure mains, is made in the form of a screw-plug cut-out, in which there is an air-gap between two metal surfaces separated by a sheet of mica 0·2 mm. thick, having a hole in it. This arrangement allows a spark to pass to earth when the pressure exceeds 600 volts. In the discussion, **Wilkens** stated that similar safety devices to those first mentioned had been used with metal resistances immersed in oil, but these had fused in some cases. C. K. F.

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2318. *Wattmeters and Counters for Alternate Currents.* **H. Armagnat.** (Écl. Électr. 31. pp. 237–245, May 17, 1902.)—The paper consists of a *résumé* of recent patents. G. W. DE T.

2319. *Electrical Engineering in Europe and America.* **J. Denham.** (Inst. Elect. Engin., Journ. 31. pp. 824–832, April, 1902. Paper read before the Capetown Section, Dec. 2, 1901.)—A general account of a tour undertaken by the author through England, Germany, and America. W. H. S.

2320. *Possibilities and Limitations of Electric Pumping.* **L. A. Hicks.** (Journal of Electricity, S. F. 11. pp. 216–219; 222–223; and Discussion, pp. 223–224, 1901. Paper submitted for Discussion at the Fifth Annual Convention of the Pacific Coast Electric Transmission Association, San Jose, Cal., June, 1901.) A. H. A.

2321. *Electricity in Cotton Mills.* **W. B. S. Whaley.** (Amer. Soc. Mech. Engin., Trans. 23. No. 951. pp. 769–780; Discussion, pp. 781–790, 1902.) W. H. S.

2322. *Connections of Switchgears for Electric Light and Power Purposes.* **W. E. Warrilow.** (Feilden, 6. pp. 438–447, May, and pp. 531–543, June, 1902.) G. W. DE T

2323. *Electrically Operated Air Compressors.* (Eng. and Mining Journ. 73. p. 733, May 24, 1902.)—The paper contains an illustrated description of the electrically driven air compressors, ranging in capacity from 7½ to 1,000 cubic ft. of free air per minute, manufactured by the Christensen Engineering Company. G. W. DE T.

2324. *Electricity in Mining.* **G. H. Gibson.** (Eng. and Mining Journ. 73. pp. 307–309, March 1, 1902.)—The paper refers briefly to a number of American mines where electrical machinery has recently been introduced. G. W. DE T.

GENERATORS, MOTORS, AND TRANSFORMERS.

2325. *Standardising Electrical Machinery.* (Amer. Inst. Elect. Engin., Trans. 19. pp. 705–721, May, 1902.)—This is a revision, "in view of such suggestions and extensions as experience and practice have since indicated to be desirable," of the 1897 report of the Standardisation Committee. It opens with a number of preliminary definitions, and then proceeds to the consideration, in detail, of the methods to be adopted in specifying and measuring the efficiency of electrical apparatus and equipment, classified under the following sections: Commutating Machines, Synchronous Machines, Synchronous Commutating Machines, Rectifying Machines, Stationary Induction Apparatus, Rotary Induction Apparatus, Transmission Lines. The permissible limits of temperature rise are next considered, referred to the standard conditions of a room-temperature of 25° C., a barometric pressure of 760 mm., and normal conditions of ventilation—that is, the apparatus under test should neither be exposed to draught nor enclosed, except where expressly specified. The minimum temperature limits fixed are as follows: For the fields and armatures of commutating, rectifying, and synchronous machines, 50° C., to be measured by resistance; for commutator and collector rings and brushes, 55° C., by thermometer; for the electric circuits of rotary induction machines, 50° C., by resistance; for squirrel-cage or short-circuited armatures, 55° C., by thermometer; for the electric circuits of continuous-service transformers and for reactors, induction, and magneto-regulators, 50° C., by resistance; for bearings, and for all parts not specified, 40° C., by thermometer. In any case, when the thermometric determination gives a higher value than the resistance measurement, the former is to be taken. In testing railway motors a rise of 75° C. is allowed after one hour's continuous run at 500 volts, on a stand, with the motor covers removed. Higher temperatures than those specified are allowed in cases where the insulation is of a specially heat-resisting character. It is recommended that high dielectric strength should be specified in preference to high insulation, bearing in mind the fact that the latter can be largely increased by baking, to the detriment of the former. The conditions of testing for dielectric strength for machine insulation, including the testing voltages for the various values of the rated terminal voltages, are very fully specified. The lowest testing voltage is 1,000 volts, for rated terminal voltages not exceeding 400 volts. From 2,500 to 10,000 rated voltage the testing voltage is double. From this to 20,000 volts rated, an excess of 10,000 volts is to be employed; and after 20,000 the testing voltage is to be 50 per cent. in excess of the normal. Regulation and its determination, and methods of rating receive detailed consideration. The standard voltages recommended are: For direct-current low-pressure generators, 125, 250, and 550 to 600 volts; for low-pressure circuits, direct or alternating, 110 and 220 volts; for alternating-current primary distributing circuits, an average e.m.f. of 2,200 volts; for high-pressure circuits, 6,000, 10,000, 15,000, 20,000, 30,000, and 60,000 volts. The standard frequencies suggested are 25, 60, and 120 to 140. The overload capacities recommended are: For generators, 25 per cent. for two hours; for motors, other than railway motors, and motors for intermittent service, 25 per cent. for two hours, and 50 per cent. for one minute; for synchronous con-

verters, 50 per cent. for half an hour; for transformers, 25 per cent. for two hours. Recommendations are also made with regard to photometric measurements. G. W. DE T.

2326. *Single-phase Alternators on Polyphase Circuits.* **C. O. Mailloux.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 611–621, May, 1902.)—The author describes an experiment made at Phœnix, Arizona, in which two steam-driven, single-phase alternators were run in parallel with a three-phase long-distance transmission line by means of a Scott two-three-phase transformer. A three-phase rotary converter was also on the circuit, and it was found that the three-phase generators could be switched out, the single-phase machines being held to their proper phase relation by the reactions of the converter. As soon as it was switched out they fell out of step. A. E. L.

2327. *Asynchronous Motors.* **H. S. Meyer.** (Écl. Électr. 31. pp. 423–428, June, 21, 1902.)—In this paper the author draws a comparison between induction motors of the squirrel-cage type and those having a starting resistance in the rotor circuits. He advocates the use of squirrel-cage rotors in all cases except where it is necessary to start on a heavy load with a comparatively small current. His reasons for thus recommending the squirrel-cage rotor are: (1) Simplicity of construction; (2) No rubbing contacts; (3) Great simplicity of operation; (4) The independence of the rotor of the number of stator poles. Also, the power-factor is higher because the self-induction of the rotor is a minimum, the distribution of the current in the rotor is uniform, the magnetising current is usually small on account of the low induction density in the rotor, the efficiency is high on account of the idle copper being a minimum, air friction is small, and the friction of brushes does not exist. To prove these statements, the author experimented with a three-phase motor of 7·5 h.p. at 220 volts with rotor wound first as a squirrel-cage and afterwards with collecting rings and external resistances. The results are given in the following table:—

	As Squirrel-cage Motor.	As Motor with Resistance in Rotor.
Hysteresis loss	250 watts	250 watts
Copper losses (Stator)	320 ,,	320 ,,
Friction losses	125 ,,	270 ,,
Copper losses (Rotor)	310 ,,	285 ,,
Efficiency on full load	84·9	83·2
Efficiency on half load	84·1	80·6
Power-factor on full load	89	88
Power-factor on half load	77	75·6
Maximum useful power developed	15·5 h.p.	14 h.p.
Starting couples	6·7 kg.	4·5 kg.
Starting current	114 amperes	26 amperes
Weight of copper in rotor	6 kg.	12·6 kg.

W. G. R.

2328. *Asynchronous Generators for Single- and Poly-phase Currents.* **A. Heyland.** (Elektrotechn. Zeitschr. 23. pp. 560–567, June 26, 1902. Paper read before the 10. Jahresversammlung des Verbandes Deutsch. Elektrotechniker in Düsseldorf.)—The author describes in detail the theory and con-

structional features of these machines, showing the latest improvement achieved. The machines are classed in two categories, varying slightly from each other, according to the different purposes for which they are intended. They have the advantage over the ordinary synchronous generators that they can easily run in parallel, and are quite reliable for power transmission, acting with accuracy over large ranges of load fluctuations. They can also be regulated to maintain a constant voltage, whether the load is free from induction or not. Acting as motors, they maintain $\cos\phi = 1$ for all loads, which is a decided improvement over the ordinary synchronous motors, where $\cos\phi$ becomes unity only for adjusted loads. The paper is fully illustrated. L. G

REFERENCES.

2329. *Armature Windings.* **F. Eichberg.** (Zeitschr. Elektrotechn., Wien 20. pp. 209–212, April 27, 1902.) The author applies a graphical method to the study of armature windings, with special reference to multiple wave windings. A. H

2330. *Graphical Representation of Armature Windings.* **F. Eichberg.** (Elektrotechn. Zeitschr. 23. pp. 355–356, April 17, 1902.)—Referring to Arnold's paper [see Abstract No. 1433 (1902)], and the "reduced" winding diagram therein described the author expresses the opinion that a still simpler mode of representation consists in making use of a "potential diagram," of which he gives several examples [see also preceding Reference]. A. H

2331. *Magnetic Leakage in Dynamos.* **Corsepius.** (Elektrotechn. Zeitschr. 23. pp. 395–396; Discussion, p. 396, May 1, 1902. Paper read before the Dresden Elektrotechnischer Verein, March 20, 1902.)—Some general remarks on magnetic leakage, and the analogy between a leaky electric and a magnetic circuit. A. H

2332. *Determination of Regulating Resistances for Shunt-wound Machines.* **R. Krause.** (Elektrotechn. Zeitschr. 23. pp. 383–384, May 1, 1902.)—The author considers a graphical method for determining the number of steps and value of each step in a regulating resistance for a shunt-wound dynamo. A. H

2333. *Graphical Determination of Starting Torque and Slip of Induction Motors in Relation to the Rotor Resistance.* **E. Berckenbrinck.** (Zeitschr. Elektrotechn. Wien, 20. pp. 245–246, May 18, 1902.)—The author solves this problem by the aid of Heyland's diagram, and applies the solution to the determination of the starting resistances required to obtain a given torque, and to regulate the speed of the motor. A. H

2334. *Pressure Regulation by Synchronous Converters.* **M. Seidner.** (Electrical World and Engineer, 39. pp. 761–763, May 3, and pp. 814–815, May 10, 1902.)—The author discusses, by the use of graphical methods, the effects on pressure regulation produced by varying phase displacements of p.d. and current in the case of rotary converters connected to the far end of a long transmission line. A. H

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

2335. *Roof Insulation of 15,000-Volt Lines.* (Journal of Electricity, S. F. 12. p. 89, May, 1902.)—A method is described of taking high-pressure line wires into and out of station buildings. It was devised by E. A. Beck, and, after a thoroughly satisfactory trial of two years, is being generally adopted for high-pressure work by the San Gabriel Electric Company. The conductor is encased in 1,500-volt solid rubber insulation, over which is drawn soft rubber hose, and over this again ¾-in. garden hose. Round this is a porcelain bushing 18 in. long and ½ in. thick. This is embedded in sulphur cemented into a second porcelain bushing 8 in. long and ¾ in. thick. The insulated conductor is then passed up through a glass insulator with the cap knocked off, and finally taped and painted. The insulator is screwed down over the hose until the 18-in. bushing enters the inner petticoat, when the two are sulphured together. G. W. DE T.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

2336. *Electrically Operated Plant on the North Sea Canal.* (Engineering, 73. pp. 33–35, Jan. 10; 105–107, Jan. 24; 170–172, Feb. 7; 243–245, Feb. 21; and pp. 271–274, Feb. 28, 1902.)—A full description of the North Sea Canal, the Ymuiden Locks, and the Port of Amsterdam is given, including a detailed and illustrated account of the electrically driven machinery employed for working the gates and sluices of the locks. The installation, which was the first of its kind, was carried out by the Haarlem Engine Works. The locks are provided with twelve gate-leaves, the largest of which weigh 140 tons each, and are 49·2 ft. high by 77·5 ft. wide; there are twelve chambers within the lock walls, each containing the machinery for operating one gate-leaf and one sluice, and two chambers, each containing the machinery for one capstan.

To open a gate within 80 seconds against a water-head of 4 in. requires 45 h.p. Each gate-leaf is operated by one series-wound motor, running at 360 r.p.m., in a watertight compartment. The motor drives chain-sheaves through worm-gear and double-helical gear-wheels, with a safety friction device; the chains are endless, and pull to and fro a four-wheeled carriage, which operates the gate-leaf through an iron boom. The sluices are operated through similar gear by motors, each of 17 h.p., running at 270 r.p.m. Safety devices to prevent damage to the motors in the event of the gates or sluices jamming, or by over-winding, are provided. The capstans are driven by motors, each of 21 h.p., at 270 r.p.m. through toothed and bevel gearing. In case of emergency all the apparatus can be worked by hand; the gates and sluices can also be operated by means of the capstans.

A full description of the complicated switch-gear is given. All the operations are controlled from six switch pillars on the pier-heads, the reversing switches, which are fixed in the chambers with the machinery, being operated through pilot motors. The apparatus in each switch pillar consists of two simple throw-over switches, with a "current interrupter" in the base

of the pillar. The power and lighting plant consists of two 75-kw. generating sets, and two engines driving smaller dynamos, together with a storage battery; light is supplied on the three-wire, and power on the two-wire system, at 350 volts. There are twelve 10-ampere arc lamps and five hundred glow lamps. The cables are all underground or under water; the former are lead-sheathed, the latter lead-sheathed and heavily armoured. At the Port of Amsterdam there are seven electric cranes, and a number of hydraulic cranes, driven by electric pumps, with a power-station containing two 75-kw. sets for power supply, and two 30-kw. lighting sets. A. H. A.

2337. *The Fayet-Chamonix Electric Railway.* (Engineering, 73. p. 573, May 2, 1902.)—This is a 3 ft. $3\frac{3}{8}$ in. gauge line, 10·8 miles long. The sharpest curves are 490 ft. in radius; and of the two steepest gradients, one is 9 in 100 over 1·35 miles, and the other is 8 in 100 over 0·85 mile. A third rail is employed for supplying current. At the gradients, a central rail is fixed between the track rails, on which a special shoe-brake acts, limiting the speed of descent to 6·25 miles an hour. The rails weigh 69 lbs. per yard, and the track rails are in 39-ft. lengths, held on fifteen sleepers by means of sole-plates and ordinary wood screws. Angle fishplates are used for joining the lengths of both track and brake rails. The contact rails rest on creosoted wood blocks. To prevent sliding action of the track down the gradients, a layer of concrete has been placed at intervals of 320 ft., in which old rails have been embedded; these act as abutments to the sleepers. There are two generating stations, one near Selvos and the other near Chavants, both being turbine-driven from affluents of the river Arve. The former contains four 325-h.p. central discharge turbines, revolving on horizontal shafts. The first 140 ft. of the fall are utilised for the head of water. Four 200-kw., six-pole, continuous-current dynamos are connected to the turbines by elastic insulated couplings. The turbines are placed above the tail-race, have suction pipes, work under a head of 124 ft., and develope 320 h.p. at 470 r.p.m. A 60-h.p. outflow turbine, running at 520 r.p.m., drives two 40-kw. exciters, which are also used to light the station. The second station contains two similar turbine-driven dynamos and exciter, but the head of water is here 308 ft. Each train consists of four or five cars with a luggage van, and represents a dead load of 120 tons, for about 170 passengers. The heavy gradients made it necessary that each car should be provided with motors, and that they should be controlled by one driver only, from the head of the train. The controller is worked by compressed air, and operates the electric controllers on each car. A train of five cars, at a speed of 7·45 miles an hour, absorbs on the up gradient of 9 in 100, 800 amperes at 550 volts. Starting on the same gradient absorbs about 11,000 amperes. G. W. DE T.

2338. *Syracuse Street Railway.* (Street Rly. Journ. 19. pp. 323–331, May, 1902.)—The power-station is near the centre of the system, on the Erie Canal. It contains (1) two 1,250-h.p. compound Reynolds-Corliss engines, running at 80 r.p.m., and each direct connected to an 800-kw., 12-pole, direct-current generator; (2) three 500-h.p. vertical engines, running at 400 r.p.m., each belted to three G.E. 4-mp., 300-kw. generators; (3) a vertical compound engine of 1,000 h.p. running at 125 r.p.m., and direct-connected to a G.E. 10-pole, 500-kw., direct-current generator. There are six 250-h.p. Stirling boilers, two 300-h.p. Aultman-Taylor boilers, and one 500-h.p. Abendroth and Root boiler. There are two Snow duplex feed-pumps, each

12 in. × 6 in. × 10 in., and a Wheeler feed-water heater. The steam loop with the Holly gravity return system is used on the boilers. The steam pressure of the plant is 160 lbs. A gravity oiling system is employed, the requisite pressure being obtained from a storage tank on the roof. Compressed air at a pressure of 80 lbs., supplied by a steam air pump, is used for cleaning the dynamos, in place of dusting. The erection of a cooling tower is contemplated, as the feed-water is extremely bad. At present, Lagonda mechanical boiler-tube cleaners are in regular use for the removal of scale. One of these cleaners has gone through a 4-in. tube 20 ft. long, plugged full of scale, in seven minutes. A specially designed hydraulic hoist is employed for removing wheels or trucks from the cars, and has been found capable of changing a pair of wheels in twenty-eight minutes. Each car has four G.E.-54 motors. Christensen air-brakes are employed. Each car carries forty-four passengers. The track is ballasted almost entirely with stone, and the rails are laid on ties 6 in. × 8 in. × 8 ft. Within the city, the rails are partly grooved and partly plain tram-head, weighing 90 lbs. per yd. The guard rails weigh 117 lbs. per yd. The overhead work is partly side-pole and partly span.

G. W. DE T.

2339. *Houghton County Street Railway.* **W. R. Parker.** (Street Rly. Journ. 19 pp. 336–341, May, 1902.)—The power-house contains five horizontal return tubular boilers, each 72 in. in diameter, and containing 112 3-in. × 16-ft. tubes, and working at a pressure of 150 lbs. The shells and heads are of open-hearth steel, having a tensile strength of 55,000–65,000 lbs., a minimum elastic limit of 33,000 lbs., and an elongation in 8 in. of not less than 25 p.c. There are two duplex boiler feed-pumps and a Wainwright even-flow supplementary feed-water heater. The high-pressure steam-pipes are of lap-welded steel, flanged when over 2½ in.; the low-pressure ones of lap-welded iron, flanged when over 4 in. There are two units, one for railway work and one for supplying power to the three-phase transmission line. The former consists of a 750-h.p. horizontal cross-compound condensing Corliss engine, direct-connected to a Westinghouse 10-pole, 500-kw., 550-volt railway generator running at 90 r.p.m. The working pressure is 125 lbs. At full load, and with a vacuum of 25 in. at the exhaust, the steam consumption is guaranteed not to exceed 15 lbs. per i.h.p. per hour. The full-load generator efficiency is 94 p.c., and it is guaranteed to stand a 50-p.c. overload for one hour and 75 p.c. temporarily. The transmission unit consists of a 750-h.p. horizontal cross-compound condensing engine with gridiron valves, having a cut-off varying from zero to ¾-stroke, direct-connected to a Westinghouse three-phase, 25 $\sim$, 500-kw., separately excited generator running at 100 r.p.m. The engine is guaranteed to stand a 50-p.c. overload for two hours. Each of the engines has a reheating receiver between the cylinders. The steam consumption of the second engine at full load, and with a vacuum of 26 in. at the exhaust, is guaranteed not to exceed 14 lbs. per i.h.p. per hour.

The generator has a revolving armature, and is guaranteed to develope 500 kw. continuously at 380 volts with an efficiency of 94 p.c., and 750 kw. for two hours with an efficiency of 94·5 p.c. The full-load current is 750 amperes per phase. The regulation of the generator is within 8 p.c. when the power-factor is 100 p.c., and the speed constant. For continuous running with a power-factor of 90 to 100 p.c. the temperature rise is guaranteed not to exceed 40° C. above a room temperature of 25° C. A jet condenser with vertical cross-compound air pump is employed. A

250-kw., three-phase, 25 ∼, Westinghouse synchronous converter, rated at 420 amperes at 600 volts on the direct-current side, is located in the engine-room. It is self-exciting when driven from the alternating-current side, and when driven from the direct-current side is separately excited. This and the substation converters have a full-load efficiency of 93 p.c., and are designed to stand an overload of 50 p.c. for two hours. The temperature rise is guaranteed not to exceed 40° C. above a room temperature of 25° C. on a continuous run.

There are six 100-kw., Westinghouse oil-cooled, 380–11,000-volt, three-phase transformers, having a full load efficiency of 96·7 p.c. and a voltage regulation of 2·2 p.c. when the power-factor is 100 p.c. One side of the substation contains six 100-kw., 11,000–380-volt transformers, and on the other side are two 250-kw., three-phase, rotary converters, delivering current to the feeders at 600 volts. The transmission line, some 12 miles long, is supported on the railway poles with triple petticoat insulators guaranteed for a working pressure of 15,000 volts. The 30 and 60-lb. T-rails, of A.S.C.E. section, are laid on cedar ties 2 ft. apart. The overhead construction is of the top-guy flexible bracket type strung with No. 00 trolley wire. 35-ft. cedar poles are used with an 8-in. top, and carry three cross-arms for the transmission and feed wires. The larger cars, which carry 40 passengers, are provided with four 38-h.p. G.E. motors, and four smaller cars are provided with two similar motors. Air brakes are employed. G. W. DE T.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

2340. *Train Resistance.* **W. J. Davis, Jr.** (Street Rly. Journ. 19 pp. 360–362; Discussion, pp. 362–367, May, and pp. 460–461, June, 1902.)—The author, in view of the present tendency towards high speed, calls attention to the importance of obtaining a rational formula for train resistance in place of the empirical ones now in use. The items to be considered are, according to him: (1) journal friction, taken as independent of speed; (2) rail friction, assumed to vary as the speed; (3) wind resistance, varying as the square of the speed, with the cross-section and end shape of the car, and with the number of cars forming a train. He writes down such a formula in the most general form, and determines the constants from tests made by him on a train composed of a locomotive, baggage car, and three standard passenger coaches of the Erie Railroad, weighing on an average 26 tons each without load. The train was quickly brought up to maximum speed, when the power was thrown off and the train allowed to coast. Curves were obtained showing the variation of speed with time and with distance, with the locomotive alone, and with it and one, two, three, and four cars respectively. Examples of these curves are given. The formula so obtained is—

$$f = 4 + 0{\cdot}13V + 0{\cdot}004AV^2\{1 + 0{\cdot}1(n-1)\}/T,$$

in which f = friction in lbs. per ton; V = velocity in miles per hour; T = weight of train in tons; A = cross-section of car in sq. ft., including trucks, motors, &c.; n = number of cars, including locomotive. The cross-section A comprises the section of the car body proper plus the section bounded by the car wheels, the underside of the car body, and a horizontal

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

line, tangent to the head of the rails, and normal thereto. *Discussion.*—**J. Lundie** criticises the method employed in obtaining the formula. He considers that important items are omitted by the author, *e.g.*, the lack of perfect resilience in the parts, both of the track and rolling stock, which are under strain. He proposes a formula, which, in addition to minor modifications, substitutes the first power of the speed for the square. **S. T. Dodd** insists on the importance of obtaining more extended data, and points out discrepancies in the results given by the author's formula with those obtained in the Berlin-Zossen trials. **L. Bell** also comments on these discrepancies and distrusts the coasting method employed in the tests. **H. V. Wille** compares the author's formula with that employed at the Baldwin Locomotive Works, and finds a fairly close agreement. **The Author,** in replying to the various criticisms, maintains his conclusions, and quotes a number of experimental results tending to support them. He admits, however, the great importance of farther and exhaustive tests, especially on high street cars vestibuled at the end. He states that the General Electric Company of America is now making arrangements to conduct a series of such tests up to the highest speeds within the capacity of the track and equipment available for the purpose. G. W. DE T.

2341. *Heating of Railway Motors.* **A. H. Armstrong.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 569–592, May, 1902.)—In this paper the author attempts to outline a method of determining the probable heating and energy consumption of a given motor equipment for any class of work. He also considers very fully the possibility of arriving at some concise method of rating railway motors of such a character as to indicate with accuracy their comparative service capacity under different conditions. He has, however, been unable to devise any commercially practicable method of rating railway motors superior to the one-hour test now generally employed for this purpose. The question of the heating of motors being very closely connected with that of train resistance, he bases his calculations on the results of the tests made by W. J. Davis, Jr. [see preceding Abstract]. A large number of curves based upon the foregoing data, together with measurements taken by recording instruments, of voltage, amperes, and speed upon a time basis, are given in the paper.

The author observes that the study of these curves appears to indicate that, so far as motor heating is concerned, it is preferable to use the largest gear ratio and highest rate of acceleration possible for the accomplishment of the service contemplated, providing the maximum speeds are low, but that practically any rational rate of acceleration may be used with speeds approaching 60 miles an hour. In the choice of gear ratio for a given service, the line fluctuations, station load and energy input must be considered, as well as the motor heating with different rates of acceleration. The curves show that the possible schedule speed for a given gear ratio is controlled by the number of stops per mile, but the heating of the equipment and the proper weight of the car are found to be the same over a very wide range of schedules and stops. It is important that the equipment should be geared for the lowest possible maximum speed that will permit the maintenance of the schedule in question, as a gear ratio giving too high a maximum speed, not only overheats the motors, but produces needless demands upon the generating and distributing systems. Owing to the decreased wind resistance per car as the number of cars in a train increases, the operation of high-speed single-cars is disadvantageous from a pure energy

standpoint, but frequency of service often creates traffic, and may therefore warrant the extra expenditure for coal. Another very important point is that longer trains at greater intervals increase the fluctuation at the feeding-point. The size of the rotary converters must therefore be somewhat increased, and in all probability a larger amount of feeder copper will be required to keep the drop within the same limits. G. W. DE T.

2342. *Electro-Pneumatic Railway System.* **B. J. Arnold.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 659–662, May, 1902.)—This paper gives a preliminary account of a system of electric traction, upon the designing of which he has been engaged for a considerable time, and which is to be tried on a 60-mile length of railway, of which 20 miles are now nearly completed. The system consists essentially in the use of a single-phase (or polyphase if desired) alternate-current motor in which both the rotor and the stator, or portion which usually remains fixed, are made capable of rotation, and each is connected with an air-compressing engine and storage reservoir. This motor is designed for the average power required, and runs continuously at constant speed and constant load, and, therefore, at maximum efficiency. When the car is at rest, the stator runs at what is known as synchronous speed, which depends only on the rate of alternation of the current, and compresses air into the storage reservoir. To start the car, the air-compressor connected with the rotor is throttled, diminishing the speed of the stator. This causes the rotor to turn in the opposite direction, since the mutual action of the stator and rotor keeps the relative speed constantly at the speed of synchronism. By increasing the throttling, the speed of the rotor will be increased until it attains the speed of synchronism, when the stator will be at rest. If a still higher speed is desired, the stator is turned in the same direction as the rotor, by admitting air from the storage reservoir to the engine in connection with the former. If a higher starting effort is required than the motor can exert, then the rotor is turned by the admission of air to the engine in connection with it. This arrangement enables a car to ascend an incline at any desired speed up to the maximum, and with the motor working at its highest efficiency and imparting its full power to the car. In descending, the motor may, as desired, either utilise the full power derived from the line, or may be used to compress air with the stored energy of the train, thereby acting as a brake. In case of the supply of current being cut off for any reason, the car can be run for a considerable distance by means of the store of compressed air, and the author points out that this feature will enable a car to work on a high-pressure trolley wire over private right-of-way, and allow the trolley wire to be dispensed with, if necessary, when this ceases, so that a car can pass through a town on any line of rails, whether electrically equipped or not, until it reaches the outskirts, when it can be again connected to the trolley wire. This feature will also be of value in switching work, for each car, being independent, can leave the main-line track, and operate over switches or sidings, without complicating the yards with additional overhead or third-rail conductors, thus necessitating trolley-line conductors over the main-line track only. If a single-phase motor is used, only one overhead or third-rail conductor is required, and only one of the track rails need be used for the return, so that the other one may be left free for an automatic signal system if desired. The current can be taken into the car at any pressure up to the limit of the insulation (15,000 volts is to be used on the line now in course of construction), and led to the motor through a static transformer to effect its reduction to any desired value. The power-station

will always work at practically constant load, which will greatly reduce the requisite size of the plant and conductors. All the controlling operations are mechanical, no alteration being made in the electrical circuits, and all the operations being affected by means of the controlling lever of the motor-man, as in the systems now in use. G. W. DE T.

2343. *Comparative Acceleration Tests with Steam Locomotive and Electric Motor Cars.* **B. J. Arnold** and **W. B. Potter.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 593–610, May, 1902.)—These tests were made principally for the purpose of comparing steam and electric traction for short distance suburban service. A number of the curves obtained are given in the paper. They clearly demonstrate that during acceleration the electric motors utilise the weight upon their drivers more effectively than a steam locomotive. The electric motor, owing to its being able to maintain the maximum acceleration for a longer period, enables the same distance to be covered in the same time with a smaller expenditure of energy. Assuming that coal for a power-station may be purchased for 80 per cent. of the cost of that used in the locomotives, and that the cost of coal for electrical power is about one-third of the total cost, including maintenance and interest, the authors consider it probable that the actual gross cost of electrical power would, in this class of service, closely approximate to that of the coal consumption of the steam locomotive. Maintenance and attendance would be much in favour of electric power. G. W. DE T.

2344. *Relative Cost of Steam and Electric Railway Operation.* **B. J. Arnold.** (Amer. Inst. Elect. Engin., Trans. 19. pp. 623–657, May, 1902.)—The author was commissioned, in August, 1901, by the New York Central Railroad Company, to study the conditions governing the operation of its trains between Mott Haven Junction and Grand Central Station, and to report upon the feasibility of operating them electrically. This division consists of 5·3 miles of quadruple track, of which 2 miles are underground, and it was the annoyance caused to passengers, due to the use of steam locomotives in the tunnel, which led the company to examine into the advisability of adopting electric power. A most elaborate series of investigations was carried out by means of a dynamometer test-car inserted between the locomotives and trains run on each section of the road under ordinary service conditions, and from the results of these, and a very complete analysis of the traffic conditions, it was found that the electrical energy required to haul a ton 1 mile over the division under the existing conditions would average 63 watt-hours. No less than twelve alternative systems of electric power distribution were then examined in detail. Some of the least costly of these had to be rejected, owing to their requiring the location of power-stations in positions where their erection would probably have been prohibited by the City authorities. The system ultimately recommended was one with a combined alternate and continuous-current power-station near one end of the division, with a sub-station near the other end, with batteries in both stations. The alternate current was to be transmitted at a voltage of 11,000, and the continuous current at a voltage of 600. With this system it was found that, on the assumption that the electric locomotives would be operated by the same number of men at the same wages as those required for the steam locomotives, the total costs per locomotive-mile came out at 24·18 cents for steam and 23·63 cents for electricity. With regard to these figures, the author of the paper observes that they could be made more favourable to electricity, were an

optimistic view of many of its advantages taken, and that it was probable that in practice the gain would actually be greater. He preferred, however, to maintain a conservative view throughout the investigation, but considered it safe to conclude that the saving in working expenses by the electric system would be sufficient to offset the increased fixed charges due to the additional investment made necessary by its adoption. The constituents of the total cost were made up as follows :—

	Steam.	Electricity.
Operating expenses per locomotive-mile, exclusive of fixed charges, but including water, labour, cost of cleaning and repairing tunnel, and all other expenses of locomotive operation	23·05	15·80
Fixed changes per locomotive-mile, assuming that it now requires 40 locomotives to perform the present service, and that 33 electric locomotives could perform the same service	1·13	7·83
Total in cents	24·18	23·63

If the multiple unit system were adopted, as it would be if the electrification were extended over the rest of the line, or if the forward guard or brakeman were allowed to take the place of the second man while passing through the tunnel and yards, where two motor-men in charge of each locomotive were considered advisable, a saving in wages would be added to the foregoing. G. W. DE T.

2345. *Determination of Grades and Alignment.* (Railroad Gazette, 34 pp. 323–324, May 2, 1902. Extract from the report of the Committee on Roadways of the American Railway Engineering and Maintenance of Way Association).—In considering the question of grade with reference to economy, it is not always the grade which limits the weight or length of a train, as the limiting grade is a virtual grade which may be different from the actual one, due to a difference in velocity at the top and bottom. When the surplus energy stored in a train is drawn upon to allow of less tractive effort than would be necessary if uniform speed were maintained, we have a momentum grade. The practical problem for the engineer is to determine either (*a*) how far a steep actual grade can be continued, and yet allow a required virtual grade to be maintained, or, where an actual grade is under consideration, to determine (*b*) what the virtual grade will be under prescribed conditions of operating, and also to find (*c*) the speed which it is possible to acquire at the foot of a momentum grade. The points are dealt with at length in the report, and an interesting series of diagrams accompanies the text. C. E. A.

ELECTRIC LAMPS AND LIGHTING.

2346. *Methods of Illumination.* (Amer. Inst. Elect. Engin., Trans. 19 pp. 456–472, April, 1902.) (Discussion.)—This is a report of the discussion which took place on several papers dealing with the question of illumination. These were by Bell [see Abstract No. 1260 (1902)], Ryan [see Abstract No. 800 (1902)], Howell [see Abstract No. 1017 (1902)], Hewitt [see Abstract No. 799 (1902)], and Sharp [see Abstracts Nos. 665 and 666 (1902)]. In the discussion **J. W. Howell** said that the filament of a Nernst lamp has only $\frac{6}{10}$ of the amount of surface that carbon has at the same efficiency in watts per candle

This shows that the lamp is run at a very high temperature, and that the colour of the light is not due to any selective radiation. The projected surface of black carbon at 3 watts per candle is about 0·00325 sq. in. per candle; at the same efficiency the projected surface of grey carbon is 0·00225 sq. in., and of the Nernst lamp 0·00125 sq. in. **J. W. Lieb** said that the standards of candle-power now used in America are derived from certain standards imported from the Reichsanstalt ten years ago. A comparison was recently instituted between the Reichsanstalt standard, which is the Hefner amyl-acetate lamp, and the present American standards; and it was found that the two now differ by rather less than 2 per cent. **S. E. Doane** said that in the Bunsen photometer, the absorption of light in the grease-spot depends in part on the colour of the light, and that a three-watt lamp, compared with a four-watt lamp, would give a greater candle-power than the photometer indicates. **L. Bell** said there was some selective radiation in the case of thoria; but the only substances which have a notable selective radiation are erbia and the oxides of one or two of the rare metals which are allied with the cerium and didymium group. **T. J. Johnston** said that no flame dependent on the atmosphere for its oxygen can make a satisfactory standard of light. When carbonic acid gas or sulphurous acid gas is mixed with the air supplied to the illuminant, the candle-power is reduced in almost exact proportion to the adulteration. On the other hand, 1 per cent. of carbonic acid gas mixed with the illuminant produces a reduction of from 10 to 12 per cent. in the candle-power. W. H. S.

2347. *Arc Lighting.* **C. M. Green.** (Canad. Elect. News, 12. pp. 136–139, July, 1902.)—The author gives several characteristic curves relating to arc lamps, showing the relation between volts and amperes in an open and enclosed arc, and in an enclosed arc run with a resistance in series, and also the relation between volts and length of arc in a 5-ampere enclosed lamp. He deals also with the points necessary to ensure stability in running, and advocates the usé of enclosed lamps, worked by direct constant current, if possible. There is need for a rectifier for transforming three-phase, 25-cycle constant potential current into direct constant current for series arc lighting, the rectifier to cost less and have a higher efficiency than the motor-generator sets now employed. The Buffalo General Electric Company have at present 3,500 open arc lamps; current is supplied by twenty-six arc machines, each rated at 6,250 volts, 9·6 amperes, and driven at 500 r.p.m. by synchronous motors from Niagara. These machines are now to be rewound for 8,500 volts and 6·6 amperes, and the enclosed lamp will be adopted. Alternators and constant-current transformers would have cost twice as much as the rewinding process, and the line losses in the distributors would have been greater, seeing that 7·5 amperes would have been required in an alternate-current lamp. Boston has used the series direct-current enclosed arc system since 1898. They now have 6,000 lamps, driven by fifty arc generators, giving 8,500 volts and 6·6 amperes. W. H. S.

REFERENCES.

2348. *Electric Distribution in Paris.* **C. Marquet.** (Génie Civil, 40. pp. 346–349, March 22; 359–362, March 29; 377–380, April 5; 395–397, April 12; and pp. 410–413, April 19, 1902.)—This is a comprehensive series of papers dealing with the distribution of electric light and power in Paris, mainly from the financial standpoint, with short descriptions of the various central stations. [See also Abstract No. 2505 (1900).] G. W. DE T.

2349. *City of Mexico Transmission System.* **S. Q. Hayes.** (Elect. World and Engineer, 39. pp. 465–471, March 15 ; 503–507, March 22 ; and pp. 545–548, March 29 1902.)—These papers give a very full description, with diagrams and other illustrations, of the system dealt with in Abstract No. 595 (1902). G. W. DE T.

2350. *Niagara Falls Power Transmission Plant.* **H. W. Buck.** (Amer. Inst. Elect Engin., Trans. 19. pp. 531–546, May, 1902.)—The paper deals with details of the new generator, the exciter plant, the main switchboard, and the methods of interconnecting the American and Canadian power systems. [See also Abstracts Nos. 412 and 1629 (1902).] G. W. DE T.

2351. *High-Speed Railways.* **F. B. Behr.** (Zeitschr. Vereines Deutsch. Ing. 46 pp. 486–493, April 5 ; 517–519 ; and Discussion, pp. 519–523, April 12, 1902. Paper read before the Berlin Bezirks-verein.)—The paper advocates the "Mono-rail" system for high-speed work, and gives some illustrations of the Listowel-Ballybunion line, and sectional drawings and details of the "Mono-rail" line near Brussels, and of the projected one between Manchester and Liverpool. The signalling system proposed for the latter is also fully described, with sectional drawings. [See also Abstract No. 1440 (1901).] G. W. DE T.

2352. *Electric Traction.* **J. C. Robinson.** (Soc. Arts, Journ. 50. pp. 408–421 Discussion, 421–424, March 21, 1902.)—The paper deals with the development, present condition, and probable future expansion of electric tramways and tube railways, mainly from the economical and legislative points of view. G. W. DE T.

2353. *Block Signals on Heavy Electric Railroads.* (Street Rly. Journ. 19. pp. 255–262, April, 1902.)—The paper is supplementary to one by H. S. Knowlton [see Abstract No. 2489 (1901)], and gives a detailed description, with sectional drawings, of the apparatus employed on the elevated railways in Boston and Chicago. G. W. DE T.

2354. *Street Railway Wheel Sections.* (Street Rly. Journ. 19. pp. 265–267, April, 1902.)—The paper consists of a series of dimension drawings and descriptions of wheel sections taken from a number of sources and illustrating a great variety of forms now in use. G. W. DE T.

2355. *Analysis of Street Railway Operations in Germany.* **W. Mattersdorff.** (Street Rly. Journ. 19. pp. 291–295, April, 1902.)—This is an abstract by the author of a paper in the *Zeitschrift für Kleinbahnen*, and contains numerous curves and tables dealing with the costs, traffic density, and other operating conditions of a number of German tramways. G. W. DE T.

2356. *Insulation of Trolley Wires.* **J. B. Pomey.** (Écl. Électr. 31. pp. 5–7, April 5, 1902.)—The author gives a mathematical solution of certain particular cases where difficulties are encountered in fault-testing by the voltmeter method. M. O'G.

TELEGRAPHY AND TELEPHONY.

2357. *Automatic Relay Translation for Long Submarine Cables.* **S. G. Brown.** (Inst. Elect. Engin., Journ. 31. pp. 1060–1075; Discussion, pp. 1075–1085, June, 1902.)—With very feeble currents, "butt" contacts in a relay will not work, since the resistance of such a contact may be many thousands of ohms; while, if the local battery is increased so as to break down this resistance, the contact coheres. The author finds that the revolving contact pieces proposed by Varley in 1862 do not remedy the difficulty; he himself prefers to press the end of the relay tongue upon the surface of a divided plate. If this plate is caused to move, sensitiveness and good contact are secured. Following up this idea, the author causes the relay

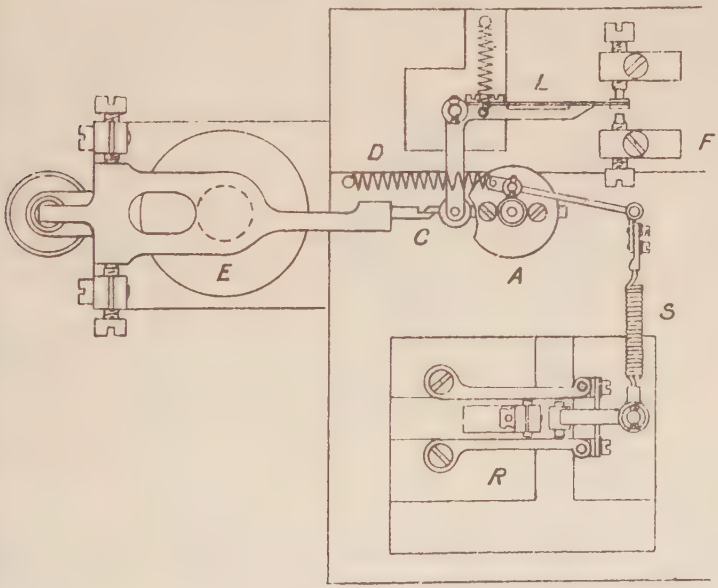

FIG. 1.

tongue to bear upon the surface of a rotary drum, the latter being divided into insulated sections, and the sections joined to P.O. or other relays. The movement of the recorder-coil by means of two silk or quartz fibres joined to its shoulders, and to the frame carrying the tongue, causes the extremity of the tongue to move over the drum in a comparatively large arc. The tongue consists of a fine siphon tube carrying a bronze wire tipped with iridium. The drum revolves about 150 times in a minute. The relay depends for its efficiency upon the reduction of frictional resistance to the lateral movements of the tongue, due to tangential motion of the surface. If the drum is stopped, the tongue also stops moving, the cable currents being too feeble to overcome the statical friction between tongue and surface. A condenser of 2 m.f. is used in circuit with each half of the drum, and the tongue end is found to

improve the contact. There is a receiving condenser, as usual, to curb signals and exclude earth currents. The "Variable Zero" due to the accumulation of charge in this condenser has to be dealt with. The author and A. L. Dearlove had found that this could be got rid of by a high resistance shunt across the receiving and transmitting condensers, but that with such an arrangement earth currents made themselves perceptible. The author prefers "Local Correction," which he applies as follows: A current from a local battery and the recording relays is sent through a circuit having considerable retardation, made up of a condenser placed between two high resistances, all capable of minute adjustment. The arrangement is such that by a separate winding on the suspended coil, the correction current compensates for the gradual dying away of the cable current. An inductive shunt is also used across the terminal of the suspended coil, of 30 ohms resistance, for steadying and curbing the latter, and so increasing speed. The shunt has many thousand turns of copper wire and a heavy closed magnetic circuit. It is found that, with the feeble currents from the cable, the

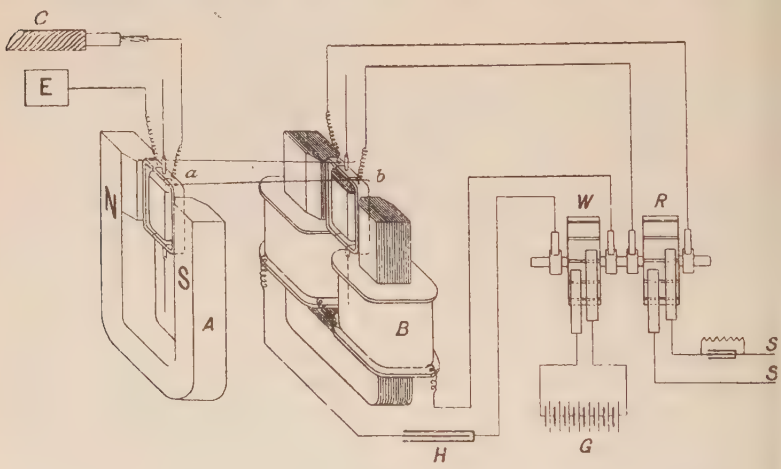

FIG. 2.

iron is only magnetised in its initial stage, and the retentiveness may be disregarded. Thus far, the apparatus described is suitable for translation at key-speed. For automatic transmission, the author employs an "interpolator" to reproduce the signals which are dropped at high speed when successive impulses of the same sign occur. It should run in approximate synchronism with the transmitter. It has two sets of signalling levers, similar, but mechanically distinct. Fig. 1 shows the half which transmits the "dots." The electromagnet E is worked from one of the ordinary relays which are in circuit with the drum relay. The lowering of the armature removes the catch C from the clutch-sleeve A, which revolves, and moves the lever L putting battery to line. A crank-pin on A also revolves, and by means of a spring S, rocks the reverser R to which the battery is connected and this, at stated times in the revolution, reverses the battery, which acts as a curb to the first battery current, or cutting off the battery and putting the line to earth, acts as "plain" automatic. Thus a long contact at the drum relay, due to the running together of two or more dots, is split up by the "Interpolator" into its component parts, and

retransmitted as such. In place of the "interpolator," an "automatic perforator" may be employed. In this case there are three instead of two clutches, which operate punches, by means of cams, for perforating the tape. With this tape, other instruments can be fed with the least delay. Slight failures in the relay must necessarily be at once detected, consequently there are two local registers, one showing the drum and tongue contacts, the other the signals actually sent into the second cable. The author exhibits actual tapes showing the recorder trace for the drum relay, single and duplex, and the rectification of the signals by the interpolator. Finally, the "magnifying relay," the forerunner of the "drum cable relay," is described. Fig. 2 explains its arrangement. Field coils B are the seat of an alternating current. When the coil *b* is moved, there is an induced current from the field. This is rectified by R, and can then work a siphon recorder or other instrument by leads *ss*. By plugging in capacity, the period of the coil is increased, and by using induction, the period is reduced. Thus a ready means of adjustment is available. The instrument promises to be very useful for amplifying cable signals, and tapes were exhibited in illustration of this fact. It will permit of a reduced sending battery, or of greater speed with an existing battery, and possibly allow of a direct writer being used in place of a siphon recorder. It might, further, be employed to test and compare a complex circuit, the deflection showing the resultant capacity or induction; for, if the alternating current in the field is of sine-wave form, and induction or capacity is introduced in the circuit of the moving coil, the rectifier being dispensed with, and the coil suitably adjusted, it will move one way for induction and the other for capacity. This line of investigation was suggested by H. A. Taylor and A. L. Dearlove. *Discussion.*—**Ayrton** thought the apparatus was the first successful solution of the difficulty of transforming the blurred signals of a siphon recorder in a long cable into ordinary Morse signals, and the mode of restoring the waves that have disappeared extremely ingenious. The synchronism between the sending instrument and the interpolator is essential for the production of the proper number of ripples that have been blurred out in transmission. **H. W. Sullivan** did not consider that "butt" contacts were so troublesome as stated. **H. D. Wilkinson** was of opinion that the reproduction of the missing ripples was not of so much consequence as the utilisation of the extremely feeble force available for translation and the control of a wandering zero, which the author had so well dealt with. In reply, **S. G. Brown** remarked that at very high speeds synchronism was automatic. Vibration had been suggested for the relay tongue instead of the sliding contact, but it had been found, with vibration, that the contact was not long enough, and that the film of oxide on the surfaces did not always disappear when a hammer contact was made, and this might be a considerable obstacle. This last is an objection to "butt" contacts. The use of the "interpolator" on long cables is not indispensable. E. O. W.

2358. *Wireless Telegraphy.* **M. Ascoli.** (Elettricista, Rome, 11. pp. 142–143, June, 1902.)—A transmitter may be tuned to any one of a number of receivers by keeping the induction coil going and bringing an iron core to a definite position within it. Slight movements of the core will make the required signals, which will only make a continuous line, instead of dots and dashes, in an untuned spy receiver. A. D.

2359. *Multiplexing the Telegraphone.* (Elect. World and Engineer, 39. p. 911, May 24, 1902.)—P. O. Pederson has recently patented a method of

using the Poulsen telegraphone in such a way as to record a number of messages on a single steel strip, and to reproduce each message without interference from the others, enabling a long speech or a number of signals to be stored upon a comparatively short strip. The invention consists essentially in the use of two or more recording magnets, the connections of which are varied for each message with the corresponding variation in the combined action of the magnets on the recording strip. To reproduce any given message, the connections of the magnets must be adjusted to the same combination that was used in impressing it. [See also Abstract No. 476 (1901).] G. W. DE T.

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2360. *Speed of Transmission on Submarine Telegraph Cables.* **Devaux-Charbonnel.** (Écl. Électr. 31. pp. 124–133, April 26; and pp. 170–177, May 3, 1902.)—The author investigates mathematically the problem of predetermining the speed of transmission in the design of submarine cables, and verifies his conclusions by comparison with the results obtained in working various existing cables. G. W. DE T.

2361. *Long-distance Telegraph Cables.* **J. H. West.** (Elektrotechn. Zeitschr. 23. pp. 430–431, May 15, 1902.)—In connection with inter-town communication, as the wires increase in number it becomes increasingly difficult to send messages free from disturbance. The author compares overhead and underground cables, showing how considerations of capacity and inductance enter into the question. He then gives sketches of various suggested cables, having paper or other insulating material, which he considers preferable to present forms. P. E. S.

2362. *Wireless Telegraphy in Spain.* **E. Guarini.** (Electrician, 48. pp. 1006–1009, April 18, 1902.)—The author describes the transmitting and receiving apparatus used by Cervera in his 1901 experiments between Ceuta and Algeciras. G. W. DE T.

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In Light :—Absorption; Dispersion; Interference; Measurements and Use of Instruments; Miscellaneous; Phosphorescence and Fluorescence; Photography; Photometry; Polarisation; Rays and Radiation; Reflection of Light; Refraction of Light; Spectra; Vision; Zeeman Effect and Radiation in a Magnetic Field.

In Heat :—Absorption; Conductivity; Critical Points and Constants; Dilatation; Freezing-, Melting-, and Boiling-Points; Gases and Vapours; Measurements and Use of Instruments; Miscellaneous; Specific Heat and Latent Heat; Temperature; Temperatures (high and low); Thermodynamics; Thermometry and Pyrometry; Vapour Pressure.

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In Electricity and Magnetism :—Absorption; Alternate Current Research; Apparatus and Instruments (descriptive); Capacity (electrostatic); Conductivity and Resistivity; Dielectrics; Discharge in Gases and in Vacuo; Electromagnetic Theory; Induction (self and mutual); Magnetism; Measurements and Use of Instruments; Electro-Physiology and Electro-Therapeutics; Miscellaneous; Oscillations and Waves; Polarisation (electric waves); Polarisation (electrolytic); Resonance; Static and Atmospheric Electricity; Terrestrial Magnetism and Electricity; Thermo-Electricity and Thermo-Magnetism.

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